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EFFECT OF 2,4 – DICHLORO– 1 –NAPHTHOL ON THE RATE OF DEVELOPMENT AND VIABILITY IN *DROSOPHILA MELANOGASTER*

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(Received 30 September 1978)

Chlorinated naphthalenes are polycyclic hydrocarbons of industrial importance and some of these are known to be pollutants. 2,4-Dichloro-1-naphthol is one such compound which has been tested to evaluate its effects on the rate of development and survival value in *Drosophila melanogaster*. The present findings have shown that this polycyclic hydrocarbon not only prolongs the rate of development but also interferes with viability. 30 mg /100 ml food medium has been estimated to be the LC_{50} dose on the test system under study.

(Key words: **2,4–Dichloro-1-naphthol,** *Drosophila melanogaster)*

INTRODUCTION

Polycyclic hydrocarbons are an important group of chemicals, some of which form a part of the physiological system of man and several animals while others are found as part of the environment. Some of these are employed as pesticides, drugs and many of them are present in diesel fumes, cigarette smoke, smoked foods and various industrial effluents (LUCAS, 1975). Chlorinated nephthalenes as industrial pollutants are known to cause necrosis of the liver and thereby induce toxic jaundice (cf. HARDIE, 1964). 2, 4–Dichloro–l–naphthol is one such chlorinated naphthalene used in electrical industry, cable covering composition and in storage batteries. Hence man is some way exposed to this chemical. This prompted the present investigation to be undertaken on *Drosophila melanogaster* as a test system to understand its effects. As a part of these studies experiments were conducted to analyse the effect of this chemical on the rate of development and viability, the results of which are herein presented.

MATERIALS AND METHODS

Oregon-K strain of *Drosophila melanogaster* has been used in the present investigations. Variable concentrations of 10, 20, 30, 40, 50, 75 and 100 mg of 2,4–Dicholoro–1–naphthol (BDH, England) was thoroughly mixed in 100 ml of wheat cream agar medium and tested for their effects. Eggs were collected by Delcour's technique (1969). The eggs of the same age ($\pm$4 hrs) in equal numbers of 35 eggs were placed in each vial (3" $\times$ 1") containing separately normal and chemical supplemented media.

Twenty replicates were used for each treatment. The flies emerged were scored and the sex ratio was recorded every day from the day of eclosion to the last day of emergence in each vial. The data obtained were used to calculate the pattern of emergence and the mean developmental time of the whole group and of the two sexes in each of the concentrations and control. The degree of toxicity of the chemical has been evaluated by analysing the rate of mortality. All the experiments were carrried out at a constant temperature of 24 $\pm$ 1°C.

RESULTS

Fig. 1 shows the pattern of emergence of flies in different concentrations and in control. The mean developmental time for different groups and for the two sexes in

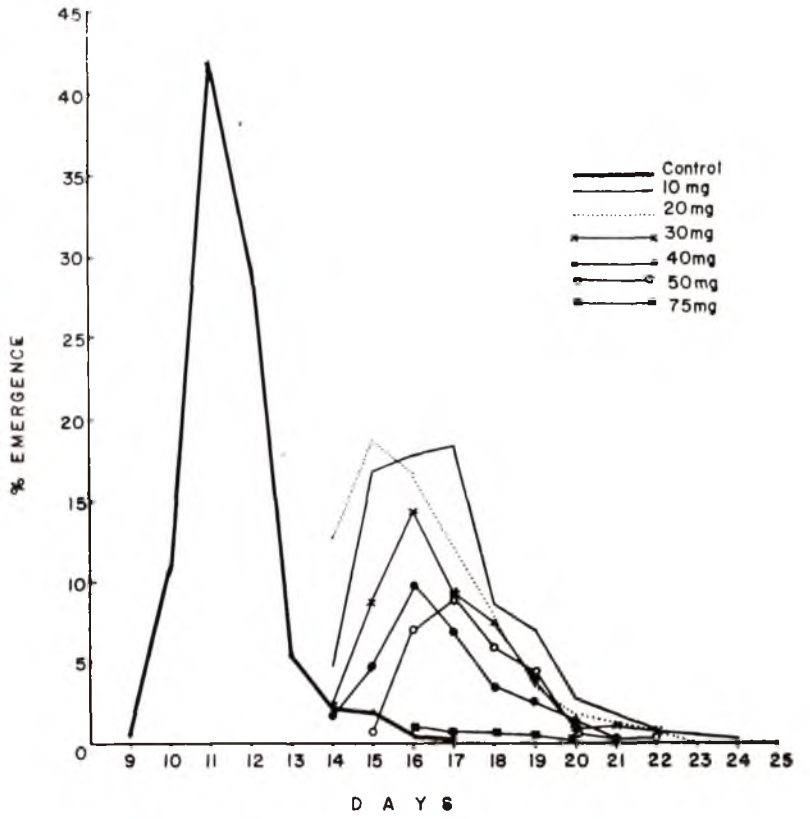

Fig. 1. Pattern of emergence of flies in control and in different concentrations of 2,4-Dichloro-1-naphthol in *Drosophila melanogaster*.

each group are presented in Table 1. The mean developmental time in control is 11.51 ± 0.07 days while it is prolonged in all concentrations tested. Thus the mean developmental time is 16.76 ± 0.08, 16.19 ± 0.18, 16.81 ± 0.11, 16.64 ± 0.10, 17.43 ± 0.10, 17.5 ± 0.47 and 16.66 ± 0 days for 10, 20, 30, 40, 50, 75 and 100 mg respectively.

Table 2 shows the percentage of lethality which is a measure of toxicity. The number of flies emerged out of 700 eggs in control is 655 which indicates a lethality of 6.43%; at the lowest concentration of 10 mg the lethality is 20.5% while in the highest concentration of 100 mg employed it is 99.57%. The LC_{50} estimated is 30 mg/100 ml of food medium. The results show that the percentage of lethality is directly proportional to the concentration.

Summary of the χ^2 homogeneity test for survival of males and females are shown in Table 3.

The authors have observed pupal death and mortality of flies in a partially emerged state in certain higher concentrations of the chemical tested. Further flies with bent wings, spread wings and wings of reduced size were also found in treated series.

DISCUSSION

LUNING (1966) has shown that the rate of development and survival value are the

two parameters by which the toxicity of the chemical is measured. Change in the rate of development is due to the compound effect of several causes both in genotype and the environment (BONNIER, 1960). The latter includes crowding, temperature, space etc. In the present investigations the space, the amount of food, the temperature, number of eggs per vial and the genetic contents were not variables, suggesting that the difference in the rate of development may be due to the different concentrations of the chemical.

In the present experiment the data shows that 2,4–Dichloro–1–naphthol prolongs the rate of development even at the lowest concentration employed (11.51 ± 0.07 to 16.76 ± 0.08) (Table 1). Statistical analysis made on the mean developmental time in different concentrations compared to control has shown significant values ($P < 0.05$) (Table 1). The authors opine this may be due to various somatic effects caused by the chemical. LUNING (1966) using sodium salicylate and other compounds, SORSA & PFEIFER (1973) using certain organomercurials, VASUDEV & KRISHNAMURTHY (1977 a, b) and VASUDEV *et al.* (1978) using Dithane, lead compound and aspirin, RAJASEKARASETTY *et al.* (1978) using ceresan dry on *D. melanogaster* have come to a similar conclusion. FISHER (1975) has demonstrated that some chlorinated hydrocarbons reduce the rate of cell division in marine phytoplankton thereby causing deleterious effects on marine ecosystem.

The test for survival value (Table 2) indicates that 2, 4–Dichloro–1–naphthol induces lethality and the results show that the concentrations above 30 mg/100 ml of food medium reduce the viability significantly ($P < 0.05$). There is a linear relationship between the concentrations and the percentage of lethality. This dose response on lethality has also been reported by earlier investigators (SORSA & PFEIFER, 1973;

TABLE 1. Mean developmental time of *D. melanogaster* in different concentrations of 2,4–Dichloro-1–naphthol and in control.

Concentrations	Mean developmental time		
	For group	For Males	For Females
Control	11.51 ± 0.07	11.54 ± 0.11	11.34 ± 0.21
10 mg	16.76 ± 0.08*	16.75 ± 0.11	16.78 ± 0.19
20 mg	16.19 ± 0.08*	16.27 ± 0.2	16.10 ± 0.19
30 mg	16.81 ± 0.11*	16.73 ± 0.18	16.88 ± 0.21
40 mg	16.64 ± 0.10*	16.75 ± 0.25	16.54 ± 0.20
50 mg	17.43 ± 0.10*	17.22 ± 0.13	17.57 ± 0.19
75 mg	17.5 ± 0.47*	17.20 ± 1.43	17.8 ± 0.76
100 mg	16.66 ± 0.66*	18.0 ± 0	16.0 ± 0

* Control Vs treatment by Student t–test; $P < 0.05$.

TABLE 2. Toxicity of 2,4–Dichloro–1–naphthol in *D. melanogaster*.

Concentrations	No. of adults emerged out of 700 eggs	Mean No. of offsprings/ vial	Lethality %
Control	655	32.75 ± 0.45	6.43
10 mg	557	27.85 ± 0.83	20.5
20 mg	538	26.9 ± 0.86	23.05
30 mg	352	18.53 ± 1.02	50.28*
40 mg	218	11.47 ± 1.04	68.86*
50 mg	193	10.72 ± 1.29	72.3*
75 mg	10	1.67 ± 0.33	98.57*
100 mg	3	0.15 ± 0. 5	99.57*

* Treatment Vs control by analysis of variance; $P < 0.05$.

TABLE 3. Summary of χ^2 homogeneity test for viability of males and females in each treatment.

Concentrations	Males	Females	χ^2
Control	331	324	0.07
10 mg	264	293	1.51
20 mg	271	267	0.03
30 mg	166	186	1.14
40 mg	104	114	0.46
50 mg	75	118	9.58*
75 mg	5	5	0. 0
100 mg	1	2	0.33

* P Value is significant at 5% level.

LAAMANEN *et al.*, 1976; VASUDEV & KRISHNAMURTHY, 1977 a, b; VASUDEV *et al.*, 1978; RAJASEKHARASETTY *et al.*, (1978).

The high death rate of pupae and the partially emerged flies observed by the authors may be due to the suppression of genetic programming at the level of events of rupture of pupa as well as at the time of emergence. It is of interest to recollect that many of the polycyclics are known to intercalate into DNA and are said to convert into epoxides by microsomal enzyme systems (cf, AMES *et al.*, 1972). Chemical induced abnormalities such as bent wings, spread wings and reduced wing size observ ed

by the authors tally with the findings of the earlier workers (LEVAN, 1945; VASUDEV & KRISHNAMURTHY, 1977).

The sex ratio is not significantly affected by the chemical ($P > 0.05$; Table 3) except in 50 mg concentration where females are more in number than males which is significant ($P < 0.05$).

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SEXUAL COMPETITIVENESS OF GAMMA-IRRADIATED ADULT RICE-MOTH, *CORCYRA CEPHALONICA* STAINT.

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(Received 31 January 1979)

Freshly emerged male *Corcyra cephalonica* γ-irradiated at 0, 25, 35 and 45 krad, show a gradual sterility. At all doses they are, however, fully competitive with the normal males when both are caged with normal females. At 45 krad exposure, the males turn completely infertile and when caged with an equal number of irradiated females and a normal pair, their infertility and competitiveness are enhanced.

(Key words: corcyra cephalonica, **sexual competitiveness of gamma irrdiated adults)**

INTRODUCTION

The sterile-insect-release has shown a promise for achieving a successful control of rice-moth *Corcyra cephalonica*. SEHGAL & CHAND (1978) were successful in the laboratory studies in suppressing the population of rice-moth by releasing the adults which were irradiated as pupae. In this study, the evaluation of the competitiveness of the irradiated males figures prominently. It is felt that the pupal irradiation might have caused certain somatic damages that would have interfered with the sexual competitiveness of the moth. It therefore necessitated to find out such effects of γ-irradiation on the adult moths. Here we report the results obtained by irradiating the moths in the adult stage and tested for their infertility and competitiveness.

MATERIALS AND METHODS

Moths were obtained from the stock culture reared in this laboratory. Culture, and the insects throughout the present experiment were maintained as described earlier (CHAND & SEHGAL, 1978). Freshly emerged unmated moths were sexed and caged in gelatin tubes. These adults were treated in ^{60}Co irradiator (Type 220) with a dose rate of 1740 rad/min. Doses given to the moths were 0 (control), 25, 35 and 45 krad. Three types of tests were set up for different effects.

The first test was conducted to determine the effect of different doses of gamma irradiation in causing the infertility of males. After the treatment, 10 irradiated (I) males were caged with 10 unirradiated (U) females in inverted jars covered with No.16 wire-mesh lids. The eggs that fell through the wire-mesh were collected in open petri-dishes every morning for four days. Batches of 100 eggs from each collections were placed in petridishes with blackened bases, and were allowed to develop normally. Percentage hatchability and infertility were determined from the number of larvae which successfully emerged from the chorion. Also, another 100 eggs were placed in the normal diet and other culture conditions to obtain F_1 adults which were finally removed and counted. Each test was replicated 10 times.

The second test was set up to determine whether the males irradiated with gamma rays could compete sexually with the normal males. 10 I♂ from each dose were caged with 10 U♂ and 10 U♀ in inverted jars for scoring the eggs. Percentage hatchability and number of F_1 adults/100 eggs were determined and was compared with the percentage hatchability and number of F_1 adults/100 eggs from 10 pairs of untreated adults. Each test was replicated 10 times. The sexual competitiveness of the irradiated moths was quantified by the formula described earlier (SEHGAL & CHAND, 1978).

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The last test was designed to see the effects on the competitiveness of irradiated moths when an equal number of irradiated females were also caged along with the irradiated males. In this test all the moths were exposed to one dose (45 krad) which had caused 100% sterility. The different densities in which the various combinations of I♂ : I♀ : U♂ : U♀ were caged together were 10:10: 10:10, 10:10:2:2, 10:10: 1:1 and 15:15: 1:1 besides a set of 10 U♂ and 10 U♀ (control) and a set of 10 I♂ and 10 I♀. Each flooding ratio was replicated 10 times. The percentage egg-hatch and the number of F_1 adults/100 eggs were determined. The corrected expected fertility was calculated and competitiveness values (CV) were also estimated as before. In all the cases CV near 1.0 shows full competitiveness. $CV > 1.0$ indicates that the irradiated males are more competitive.

At appropriate places, data were subjected to analysis of variance and the differences between means were tested by the Studen-Newman-Keuls test (SOKAL & ROHLF, 1969).

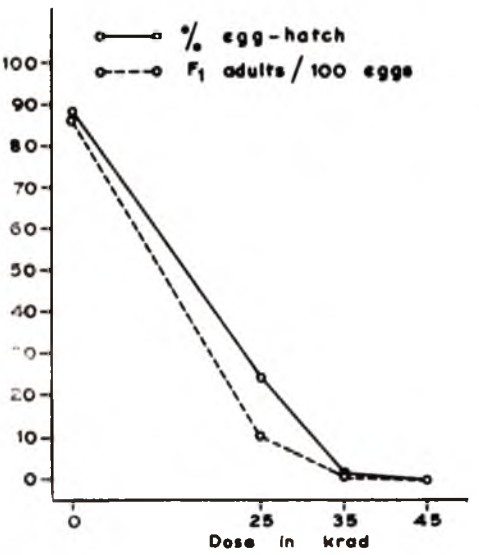

Fig. 1. Effect of γ – irradiation of male *C. cephalonica* on fertility as shown by % egg hatch and F_1 progeny/100 eggs.

RESULTS

The eggs collected from unirradiated pair of moths showed 87.6% hatch. When the males treated with 25 and 35 krad were paired with the unirradiated females, their eggs respectively had 23.4% and 1.5% hatchability. The hatch was reduced to zero when the dose was increased to 45 krad (Fig. 1). Similar effect was observed on the formation of F_1 adult from the eggs derived from the crosses between the normal females and irradiated males. Unirradiated females confined with the males irradiated with 25 and 35 krad produced 10.2 and 1.2 F_1 adults/100 eggs respectively, while from a normal pair 86.3 adults/100 eggs were obtained.

Table 1 reveals the results of the second test in which U♀ when caged with both unirradiated and irradiated males in the ratio of 1:1:1. The number of eggs produced in these crosses showed a significant ($P < 0.05$) gradual decrease from 268.57 eggs/♀ in the control (0 krad) to 178.61 eggs/♀, in the set where males were exposed 45 krad. Similarly the number of egg-hatch was reduced from 88.29% to 12.17% when the males were treated from 0 to 45 krad. The increase in the irradiation dose not only reduced the egg hatch but also the number of F_1 adults/100 eggs was significantly ($P < 0.01$) lowered from 87.21/100 eggs to 10.65/100 eggs. With all these doses, this number is much higher than the number of F_1 adults emerged in the previous cross where the U♂ were not confined with I♂ × U♀. This test also gives the competitiveness values of the males irradiated with different doses. In all the treatments, the males were fully competitive with the normal males ($CV > 1.0$).

Since the dose of 45 krad caused 100% sterility (as shown in the first test), this dose was, therefore, selected for the third test where the same number of irradiated females were also confined with I♂, U♂ and U♀. The results of these crosses showed that the percentage of egg hatch of 42.93% from the

ratio 1:1:1:1 (I♂ : I ♀ : U♂ : U ♀) decreased to complete inferitility (zero % hatch) at the ratio 15:15:1:1. Comparisons with the expected per cent hatch at different ratios are given in Fig. 2. The number of F_1 progeny (per 100 eggs) fell from 85.8 from a control pair (0:0:1:1) to 25.62 at the ratio 1:1:1:1 (Table 2).

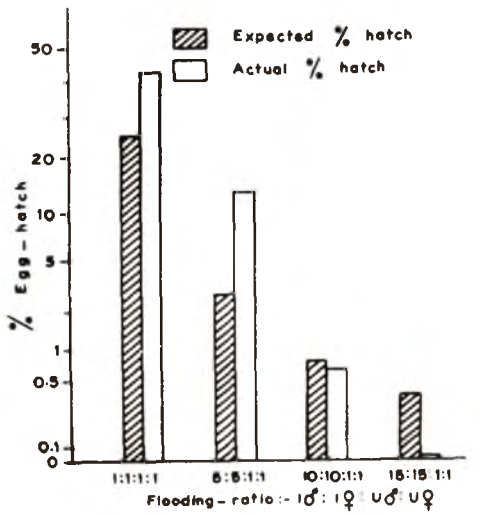

Fig. 2. Expected egg hatch in relation to observed egg hatch when an equal number of irradiated males and females in different flooding ratios were caged with an irradiated pair. Note the log scale on the ordinate has accentuated the small values.

When the actual egg hatch from the cross with ratio 1:1:1:1 is compared with expected percent hatch, the competitiveness value was 0.73 (Table 2). However, when the ratio of the irradiated to unirradiated was increased from this ratio (1:1:1:1) to 15:15:1:1, the per cent egg hatchability also decreased (from 42.93 to zero %) as expected (25% to 0.40%) (Fig. 2). The observed per cent infertility approached the corrected expected infertility resulting in the increase of competitiveness value from 0.73 to >1.0. The flooding ratio of 15:15:1:1 resulted in zero per cent hatch and C V $>$ 1.0, showing the sterile adults as fully competitive. The flooding ratio of 10:10:1:1 gave 99.21% infertility, 1.2 F_1 (per 100 eggs) and C V = 0.99. This clearly indicates that even at this ratio, the reproductive capacity of the population could be greatly reduced.

DISCUSSION

Our findings have shown that the rice-moth, *Corcyra cephalonica*, gamma irradiated at 45 krad within 24 hr of adult emergence turned completely infertile. The F_1 progeny from I♂ and U ♀ is very low at all the doses. In the field tests it is inconceivable to have a situation without any

TABLE 1. Number of eggs/ ♀ , % infertility, number of F_1 adults/100 eggs and competitiveness when the males, irradiated at different doses, were confined with untreated males and untreated females at the ratio of 10 I♂ : 10 U♂ : 10 U ♀

Dose (krad)	No. of eggs/ ♀ *	% Infertile eggs	No. of F_1 adults/ 100 eggs**	Competitiveness value (1: 1: 1)
0	268.57	11.71	87.21	..
25	240.11	65.15	29.09	1.16
35	206.82	77.36	19.64	1.38
45	178.61	87.83	10.65	1.57

* Difference between the means significant ($P<0.05$) and
** very significant ($P<0.01$) as analysed by Studen–Newman–Keuls test.

TABLE 2. Sexual competitiveness of males of *C. cephalonica* γ-irradiated at 45 krad and caged with equal number of irradiated females, unirradiated males and unirradiated females.

Ratio of the insects caged (I♂:I♀:U♂:U♀)	% egg infertility			No. of F_1 adults/ 100 eggs	Competitiveness value
	Expected	Corrected expected	Observed		
0:0:1:1	..	..	19.19	85.80	..
1:1:0:0	0.00	0.00	0.00	0.00	..
1:1:1:1	75.00	78.04	57.07	25.62	0.73
5:5:1:1	97.22	97.55	86.07	10.80	0.88
10:10:1:1	99.17	99.27	99.21	1.25	0.99
15:15:1:1	99.60	99.64	100.00	0.00	1.003

unirradiated males. In our laboratory test, therefore, an equal number of U♂ were confined with I♂ and U♀. The percentages of egg hatch and F_1 progeny from these crosses were always more than those scored from the crosses between irradiated males (at all doses) and unirradiated females only. The irradiated males were fully competitive even at low doses. The results of our study also indicate that if an equal number of irradiated female are also released, the effectiveness shows more promise. Our data further suggests that the effectiveness is enhanced when the ratio of irradiated males and females is increased. In the higher flooding ratios the sterile moths are fully competitive with the normal adults. In general these results agree with the results achieved when the pupae of *C. cephalonica* were exposed to γ-irradiation (SEHGAL & CHAND, 1978). It is, therefore, emphasised that if such a sterile-insect-release model be used for field studies, both the sexes of radiosterilized rice-moth could be released in higher flooding ratios. The expected advantages in releasing both the sexes are: it avoids the problem of sexing a very large number of moths required for such a release; secondly the release of irradiated famales nullify the effectiveness of unirradiated normal males, which otherwise would mate with normal females. Similar results of fully competitiveness were obtained by AHMED *et al.* (1976 a, b) for *Plodia interpunctella* (HUBNER) radiosterilized as pupae and adults and by WOLFENBARGER & GUERRA (1972) who studied the effects of irradiation in *Heliothis virescens* (F). FLINT & KRESIN (1968), however, had given a contrary report for *H. virescens* where they observed a decreased competitiveness in moths treated with a high dose of 45 krad of gamma irradiation. SNOW *et al.* (1972) also found adverse effect on competitiveness (CV = 0.46) in adult *Spodoptera frugiperda* sterilized with 35 krad of γ-irradiation.

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EFFECT OF RUNNING WATER ON PREDATORY BEHAVIOUR OF THE DRAGONFLY NYMPH *PANTALA FLAVESCENS* (ODONATA)

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(*Received 1 September 1978*)

Predatory efficiency of the dragonfly nymph *Pantala flavescens* was studied at 6 different water flow rates (0.0, 2.0, 4.0, 6.0, 8.0, and 10.0 l/min. The smallest nymph (125mg) tested predated 15 *Culex* larvae at the rate of flow of 0.0 l/min, and the predatory capacity decreased to 3 larvae when the flow rate was increased to 10 l/min. The predatory capacity of the nymph weighing 350 mg decreased from 20 larvae to 6 larvae when the water current was increased from a flow rate of 0 to 10 l/min. The same trend resulted when the data were calculated considering the weight of the larvae consumed.

(*Key words:* **dragonfly nymph, mosquito larvae, predations, water current**)

INTRODUCTION

MATHAVAN (1976), PANDIAN et al. (1978) and MATHAVAN & JEYAGOPAL (1978) have shown that dragonfly nymphs play an important role in mosquito control. Like other invertebrate predators such as hemipterans (ELLIS & BORDEN, 1970), coleopterans (CHRISTOPHERS, 1960; BATES, 1965) and dipterans (REDDY, 1973) odonates also predate on mosquito larvae and at times mosquito larvae form the major source of food for these nymphs. MATHAVAN & JEYAGOPAL (1978) have shown that depth of aquarium and volume of water considerably alter the predatory efficiency of the dragonfly nymph *Mesogomphus lineatus*. The dragonfly nymph *Pantala flavescens* inhabits lotic and lentic waters and also paddy fields. The speed of the running water may vary greatly in different parts of the same paddy field; the current/speed is usually greatest in the region where water enters from one paddy field to another. The present paper reports the effects of standing and running water on the predatory efficiency of the dragonfly nymph *Pantala flavescens*.

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MATERIALS AND METHODS

A mud boat with an inlet and outlet for continuous flow of water was used as aquarium. The inlet of the mud boat was connected through a rubber tube to the water tap and the flow of water was adjusted by the tap screw.

Nymphs of *Pantala flavescens* were collected from the pond "Idumban" and were maintained individually in plastic aquaria (capacity 500 ml); they were fed on mosquito larvae and acclimatized to the laboratory conditions for a period of about 10 days. The test prey consisted of (100 numbers) *Culex fatignas* larvae (4th instar) reared in the laboratory. The predatory efficiency of *Pantala flavescens* was tested in 6 different water currents— 0,2.0,4.0, 6.0, 8.0 and 10.0 1/min. The nymph was allowed to predate for 3 hours/day.

RESULTS AND DISCUSSION

The number and weight of larvae predated by different weight classes of predators at different velocities of water current are presented in Fig. 1. In standing water the larvae of *C. fatigans* aggregate themselves in small groups; as soon as water begins to flow from the inlet of the aquarium, the larvae move and anchor themselves at the edge of the aquarium. The nymph present at the bottom of the mud boat is always oriented against water current. The changes in the speed of water current influenced the predatory behaviour of the nymph very much.

All the weight classes consumed maximum number of larvae at standing water. With increasing water current, the predatory efficiency decreased. The test individual weighing 350 mg consumed 20, 18, 14, 10, 8, and 6 larvae at flow rates 0, 2.0, 4.0, 6.0, 8.0 and 10.0 l/min, respectively. Corresponding values for the nymph weighing 125 mg were 15, 13, 9, 6, 5, and 3 larvae.

In terms of weight of *C. fatigans* consumed by the nymph a similar trend was obtained. Consumption by the largest nymph tested (350 mg) decreased from 60 mg at standing water to 18 mg at a flow rate of 10 l/min (Fig. 1).

REDDY & PANDIAN (1974) reported that the predatory efficiency of the mosquito fish *Gambusia affinis* decreased with increasing velocity of water current. Similar results were obtained in the present study. The predatory efficiency precepitously declined in all the tested weight classes with increasing velocity of water current. In paddy fields and sewage channels in which water is continuously flowing the effective use of dragonfly nymphs as a predator of mosquito larvae is very much limited.

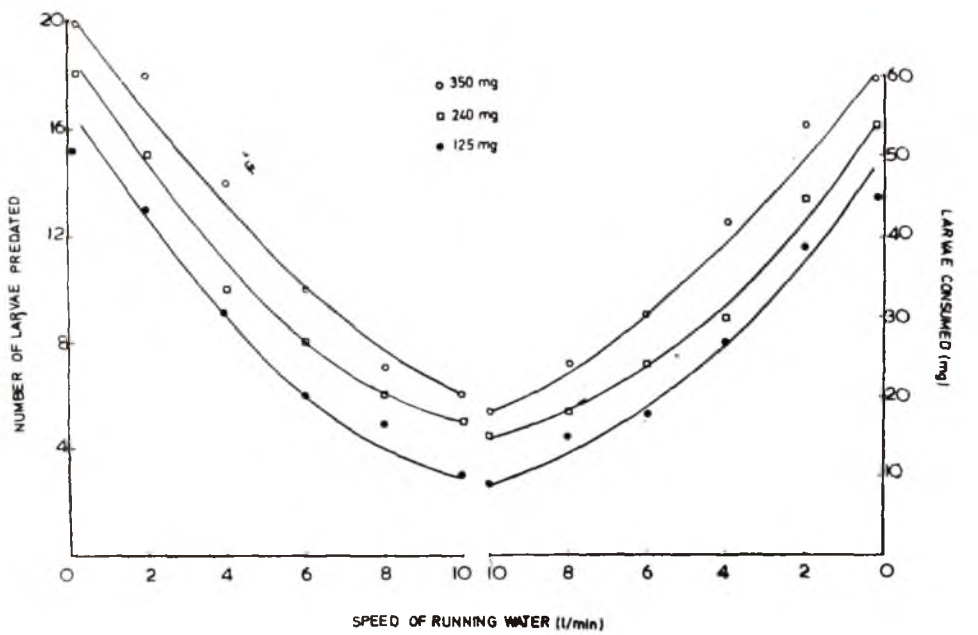

Fig. 1. Number and weight of larvae predated by the nymphs weighing 125, 240 and 350 mg as a function of water current. Each value represents an average performance of minimum of 5 individuals.

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BIOCHEMICAL CHANGES IN THE RED COTTON BUG, *DYSDERCUS CINGULATUS* F. DUE TO TREATMENTS WITH OXYTETRACYCLINE AND SULPHANILAMIDE

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The influence of oxytetracycline and sulphanilamide on the biochemical variations in the nymph and adult of *Dysdercus cingulatus* was studied. There were marked reductions both in the water soluble total carbohydrates and glycogen both in the nymph and adults. Further, the treatments also brought about an appreciable decrease in fat, protein and nucleic acid contents. Amino acid content present in the ovary also decreased. Reductions in the above nutrients were more in the nymph than the adults and the effect of oxytetracycline was more pronounced than sulphanilamide.

(*Key words:* **oxytetracycline, sulphanilamide,** *Dysdercus cingulatus*)

INTRODUCTION

Recent studies on antibiotics and sulphanilamides have shown their potentialities of inducing sterility in insects like *Dacus oleae* (TZANAKAKIS & STAVRINIDES, 1973), *Dacus cucurbitae* COQ. (CHINNARAJAN, 1972) and *Dysdercus cingulatus* F. (VENUGOPAL, 1974). These chemicals are symbionticides or antimicrobial agents and their administration through food or by other means have been observed to induce sterility in insects as reflected in the reduced fecundity, subnormal development and shortened adult longevity in several instances. While studying the biological effects of oxytetracycline and sulphanilamide on the red cotton bug, *Dysdercus cingulatus* F. investigations on the changes brought about in the biochemical components of nymph and adult stages were made to understand their role in causing such adverse effects on the reproduction and growth of the insect.

MATERIAL AND METHODS

Third instar nymphs, pre-starved for 8 hr were allowed to feed on okra seeds soaked with aqueous solutions of oxytetracycline and sulphanilamide at 0.2 per cent concentration for a day. Suitable control was also maintained with water-soaked okra seeds. Analyses of nymphs and adults were made in respect of total carbohydrates, glycogen, fats, nucleic acids, proteins and amino acids.

Total carbohydrates and glycogen: Extraction of total water-soluble carbohydrates and glycogen was done adopting the methods reported by CROMPTON & BIRT (1967). The content of total carbohydrates was determined in the acid extract colorimetrically by the anthrone method of FAIRBAIRN (1953). Glycogen was precipitated from the acid extract according to the method given by ROE *et. al.*, (1961) and analysed colorimetrically by the anthrone method of FAIRBAIRN (*loc. cit.*).

Fats: The method of FOLCH *et al.* (1957) was followed and the fat extracted at 60°C for 5 minutes (ORR, 1964).

Nucleic acids: Fresh whole body homogenates were used for estimations. The methods of ORR (*loc. cit.*) and PRICE (1969) were followed for the

preliminary separation of nucleic acids and protein. DNA was determined by the diphenylamine method (BURTON, 1956). RNA was determined by the orcinol method of MEJBAUM (1939) as modified by CERIOTTI (1950) quoted by WEBB & LEVY (1958).

Protein: Protein was assayed by following the method outlined by LOWRY *et al.* (1951).

Free amino acids in the ovary: Free amino acids in the ovary were estimated by the unidimensional paper chromatographic method (BLOCK *et al.*, 1966) and the individual amino acids were quantitatively estimated spectrophotometrically.

RESULTS AND DISCUSSION

The results are furnished in Tables 1 and 2.

Carbohydrate and glycogen

Marked variations between treated and untreated insects in the carbohydrate content were observed and the effect was very much pronounced in oxytetracycline treatment. A decrease to the extent of 93.9 per cent in the nymph, 89.1 in the female and 88.9 per cent in the male was observed in oxytetracycline treatment while in sulphanilamide the per cent reductions were 90.4, 80.1 and 67.6 in the nymph, female and male respectively. CHINNARAJAN (1972) reported meagre variation in the carbohydrate content in the antibiotic treated fruit flies, *Dacus cucurbitae* COQ. from that of untreated fruit flies. Pronounced reduction of glycogen was recorded to the extent of 93.9 per cent in the nymph, 88.6 per cent in the female and 89.1 per cent in the male due to oxytetracycline treatment. Appreciable reduction was also brought about in sulphanilamide treatment, although the decrease was only to the extent of 67.5 per cent in males.

Fat

The fat content was considerably lower in all stages of the insect treated with oxytetra-

TABLE 1. Effect of oxytetracycline and sulphanilamide on the biochemical components of *Dysdercus cingulatus* F.

Components	Oxytetracycline 0.2%			Sulphanilamide 0.2%			Control		
		Adult			Adult			Adult	
	Nymph	Female	Male	Nymph	Female	Male	Nymph	Female	Male
Carbohydrate (mg/g of fresh body weight)	0.29	0.35	0.36	0.46	0.62	1.05	4.80	3.12	3.25
Glycogen (mg/g)	0.28	0.32	0.32	0.41	0.56	0.95	4.32	2.81	2.93
Fat (mg/g)	5.60	5.18	6.35	6.28	7.10	5.60	16.00	10.60	10.40
Protein (mg/g)	2.69	1.35	6.16	3.10	1.86	6.29	6.38	3.80	9.46
RNA (μ g/g of body weight)	4.34	1.46	2.96	5.00	2.00	3.26	5.61	2.46	5.56
DNA (μ g/g of body weight)	0.58	0.86	1.80	1.27	1.73	2.58	2.16	2.31	3.90

TABLE 2. Effect of oxytetracycline and sulphanilamide on the amino acid content of ovary of *Dysdercus cingulatus* F. (μ g/g of fresh material).

Amino acids	Oxytetracycline 0.2%	Sulphanilamide 0.2%	Control
Proline	—	—	494.8
Phenylalanine	—	—	358.6
Methionine	—	—	2663.9
Valine or tryptophan	T	T	T
Alanine	—	—	T
Tyrosine	361.3	T	T
Arginine	—	—	T
Ornithine	160.7	320.3	1055.6
Cystine	162.5	218.9	90.9
Glutamic acid	—	—	270.3
Glycine	—	118.9	354.9
Threonine	605.8	—	—
Serine	160.8	—	—
Aspartic acid	198.9	—	—

T = Trace, — = Absent

cycline and sulphanilamide. A reduction of 65.0 per cent in the nymph, treated with oxytetracycline was observed as compared to control and further, the reduction was greater in the female than in male in both the treatments.

Protein

A maximum reduction of 57.8 per cent in oxytetracycline and 51.4 per cent in sulphanilamide treatments was observed in the nymph, while 64.4 and 34.8 per cent respectively was caused in female and male due to oxytetracycline treatment.

Nucleic acids

Treatments with oxytetracycline and sulphanilamide resulted in the reduction of RNA to 22.6 and 10.8 per cent in the nymph, 40.6 and 18.7 per cent in the female and 46.7 and 41.3 per cent in the male respectively. The per cent decrease recorded in respect of DNA was 73.1 in the nymph, 62.7 in the female and 53.8 in the male due to oxytetracycline treatment as compared to untreated. The effect of sulphanilamide was of lower magnitude in reducing DNA content.

Amino acids in the ovary

A general trend of reduction in the amino acid reserves due to treatments with oxytetracycline and sulphanilamide was observed. Eleven amino acids were detected in the ovary of the untreated and of these proline, phenylalanine, methionine, ornithine, cystine,

glutamic acid and glycine were present in larger proportions. Valine, tryptophan tyrosine, alanine and arginine were present only in traces. In respect of oxytetracycline treatment, tyrosine, ornithine and cystine were found in minor amounts, while valine and tryptophan occurred only in traces. Glycine, in addition to the above amino acids was also present while tyrosine and glutamic acid were observed in traces in sulphanilamide treatment. The quantum of these amino acids was comparatively greater than in oxytetracycline treatment. It was also interesting to note that in addition to threonine, serine and aspartic acid were present in the ovary of insects treated with oxytetracycline while they were totally absent in the ovaries of sulphanilamide treated and untreated insects.

Reductions in glycogen, fat and protein in *Dacus cucurbitae* treated with oxytetracline and sulphanilamide have been reported by CHINNARAJAN (1972). Actinomycin D was reported to be specific inhibitor of RNA synthesis in the larvae of *Chironomus thumni* (LAUFER *et al.*, 1964). Decrease in nucleic acids now observed in *Dysdercus cingulatus* due to treatments with oxytetracycline and sulphanilamide suggest a similar inhibitory effect by these chemicals as well.

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HORIZONTAL MOVEMENT OF PHORATE IN DIFFERENT TYPES OF SOIL

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Phorate when applied in soil as granules moves upto 60 cm in 1 day, the movement and uptake by plants being maximum in sandy soil and less in forest, laterite and red soils in that descending order; movement and uptake is very poor in alluvial soil. Maximum movement of the insecticide takes place during the first day of application.

Key words: **phorate, movement in different types of soil**

INTRODUCTION

Knowledge on the movement of systemic insecticides in soil when applied for pest control will be useful in deciding their placements and dosage in different types of soil to ensure efficiency of performance and economy. That phorate moves in soil has been reported by BARDNER & BURT (1962), ETHERIDGE & BURT (1963) and SCHULZ et al. (1973) from outside India. No Information is available on the movement behaviour of insecticides in Indian soils. Preliminary studies were hence taken up to understand the movement of phorate, an insecticide widely used for application in soils of Kerala and the present paper embodies the results.

MATERIALS AND METHODS

Five types of Kerala soils (see Table 1) collected from the representative tracts were used in these studies. The soils were air dried in shade, comminuted and sieved through a 2 mm mesh sieve. The sieved soils were filled in wooden trays 1.2 meter square and 25 cm deep to a height of 15 cm. Moisture level of the soils was kept throughout the period of the experiment at field capacity. Cowpea seeds were dibbled at different distances(Table 1) from the centre of the tray in such a way that no two seeds were in the same line from the centre. The distances at which the seeds were sown were marked at random and each replicated twice. When the seedlings were one week old 1 g of 10 per cent phorate granules was placed at the centre of the tray 5 cm deep and covered with the soil. The movement of phorate in the soils was ascertained in terms of the mortality of adults of *Aphis craccivora* KOCH confined on the seedlings and protected with cylindrical wire gauze cages on 2nd, 3rd, 5th and 8th days after applications of the insecticide. Mortality counts of the aphids were taken 24 hours after their realease on the plants.

RESULTS AND DISCUSSION

Results presented in Table 1 show that as indicated by the mortality of the aphid, phorate has moved up to plants planted 60 cm away from the point of its placement, in 1 day following the placement, in all the types of soils, excepting alluvial soil. Among these four soils the movement and uptake of the insecticide is maximum in sandy soil followed in the descending order in forest, laterite and red soils. No movement and uptake of the insecticide is indicated in alluvial soil in 1 day even at a distance of 10 cm; uptake is, however, indicated after 2 days. Decrease in per cent mortality of the aphids is registered in the soils after 1 day (after 2 days in alluvial soils) showing that the maximum movement and uptake of the toxicant takes place in

TABLE 1. Per cent mortality of *Aphis craccivora* fed on cowpea seedlings at different distances from the point of placement of phorate in different soils and after different period after placement.

Soil type	Period (days)	Distance in cm					
		10	20	30	40	50	60
Sandy soil	1	100	100	100	100	100	100
	2	100	100	100	80	70	50
	4	80	70	60	50	40	20
	7	60	50	45	30	25	10
Forest soil	1	100	90	90	80	70	70
	2	90	80	80	60	50	55
	4	60	55	50	45	40	30
	7	45	30	35	40	20	10
Laterite soil	1	100	100	90	70	60	30
	2	80	80	50	40	20	10
	4	50	40	30	10	10	5
	7	30	15	10	0	0	0
Red soil	1	100	100	95	70	60	15
	2	50	40	30	25	20	0
	4	20	10	20	10	10	0
	7	15	0	10	5	0	0
Alluvial soil	1	0	0	0	0	0	0
	2	60	55	35	20	10	0
	4	55	50	30	15	5	0
	7	0	0	0	0	0	0

one day. The low movement of phorate in laterite, red and alluvial soils may be attributed to their clay contents (which are 18.4, 15.1 and 22.7 per cent respectively as against 10.2 and 7.0 per cent in forest and sandy soils), which exert an inactivating type of chemisorption (VISALAKSHI, 1977). The poor diffusion of the insecticide in alluvial soil may also be due to its greater compaction because of the high clay content. Earlier workers like GETZIN & CHAPMAN (1960) and LINDLY (1963) also have observed that phorate is more available to plants in sandy soil than in other soils like clay-loam, peat and muck.

The practical implication of these findings are that inter-row placement of the insecticide can benefit two rows of plants in sandy, forest, laterite and red soils and that root zone placement will be needed for plants in alluvial soil. It is also indicated that less quantities of the insecticide are needed for application in sandy soil than in the other soils. Further studies are in progress.

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FIELD EVALUATION OF SOME INSECTICIDAL TREATMENTS FOR CONTROL OF *RHYACIA HERCULEA* CORTI AND DRAUT ON RABI MAIZE IN BIHAR

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Two applications of carbaryl granules at 0.5 kg a i /ha in plant whorls at monthly intervals gave the best control of *Rhyacia herculea* CORTI & DRAUDT, the climbing cutworm infesting rabi maize in Bihar. This treatment gave a net return of Rs 2526.25 per hectare as compared to untreated control.

(*Key words:* **chemical control of *Rhyacia***)

INTRODUCTION

In recent years, the climbing cutworm, *Rhyacia herculea* CORTI & DRAUDT, (Lepidoptera: Noctuidae) has become a limiting factor to rabi maize cultivation in North Bihar covering an area of 1.50 lakh hectares. The larvae feed on the tender leaves during night making numerous pinholes in their early stages and cutting the leaves on their margin in the advanced stages. During day time the larvae remain concealed in plant-whorls, feeding on them and causing formation of deadhearts. SINGH & SINHA (1965) have recorded the outbreak of this pest on young wheat and gram plants in the *diara* areas of Bihar. Results of a field trial undertaken during the *rabi* season in 1976–77 (at Agricultural Research Institute, Dholi, Bihar) are presented in this paper.

MATERIAL AND METHODS

Seeds of Hi-starch variety of Maize were sown in a randomized block design with four replications. Row to row and plant distances were 0.60 m and 0.25 m respectively. There were five insecticidal treatments and one untreated control as given in Table 1. The first application of insecticides was done when the infestation just started. Assessment of damage of plants was done 45 days after the first insecticidal application in terms of percentage of plants infested and grain yield.

RESULT AND DISCUSSION

All the insecticides provided protection to the crop and were superior to control (Table 1). The mean percentage of affected plants varied from 6.03 to 10.34 under different insecticidal treatments against 12.07 per cent in the control. The minimum infestation of 6 03 percent was observed in case of two applications of carbaryl granules at monthly interval, followed by 6.54 per cent infestation under single application of carbaryl granules; they were at par between themselves. Foliar spray of carbaryl, dimethoate and fenitrothion recorded 9.24, 10.34 and 9.15 percent of infestation respectively and all these treatments fell under the same level of significance.

All the insecticidal treatments proved superior to control in respect of grain yield. Two applications of carbaryl granules at monthly intervals gave the highest yield of 63.82 quintals per hectare (50.43 per cent over control) followed by a single granular application of carbaryl with 61.17 quintals

TABLE 1. Effect of different insecticidal treatments on control of R. *herculea* on maize, grain yield and profit.

Treatments (dose : 0.55 kg a i/ha)	Mean percentage of affected plants	Yield qt/ha	Percentage increase over control	Cost of insecticides/ ha (Rs)	Price at 120.00/ quintal (Rs)	Net profit over control (Rs)
Carbaryl granule applied once	6.54	61.17	43.96	69.50	7646.25	2263.50
Carbaryl granule applied twice at monthly intervals	6.03	63.82	50.43	139.00	7978.50	2526.25
Carbaryl suspension applied thrice at fortnightly intervals	9.24	51.17	20.42	102.00	6396.25	981.0
Dimethoate emulsion applied thrice at fortnightly intervals	10.34	50.50	18.85	284.25	6312.50	714.80
Fenitrothion emulsion applied thrice at fort- nightly intervals	9.15	55.25	30.07	142.50	6906.25	1450.50
Control-untreated	12.07	42.49	—	—	5313.25	—
SE of treatments	1.38	2.07 qt/ha				
CD at 5%	1.45	6.23 qt/ha				

per hectare (43.96 per cent increase). Statistically these two treatments were at par and significantly superior to the other treatments. The lowest grain yield of 50.50 quintals per hectare (18.85 per cent increase) was recorded in case of dimethoate followed by 51.17 quintals per hectare (20.42 per cent increase) in carbaryl spray and 55.25 quintals (30.07 per cent increase) in fenitrothion; there was no significant difference among these three treatments. By investing Rs 139.00 for two applications of carbaryl granules there was a net return of Rs 2526.25 while by investing Rs 69.50 for a single application there was a net return of Rs 2263.00. The lowest return of Rs 714.80 was from three sprayings of dimethoate costing Rs 284.25. The net return due to three sprays of carbaryl and fenitrothion were Rs 981.00 and Rs 1450.50 by spending Rs 102.00 and Rs 142.50 respectively.

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FIELD EVALUATION OF SOME INSECTICIDES AGAINST SUCKING PESTS OF POTATO

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Relative efficacy of six insecticides was evaluated against aphids, leafhoppers and whiteflies infesting potato at Udaipur, Rajasthan. The results indicated that three sprays of 0.03% dimethoate, 0.1% methamidophos, 0.03% methyl demeton and 0.03% monocrotophos at 15 days intervals starting from 65th day of planting gave significant protection to the crop against three pests.

(*Key words:* **insecticidal control, potato pests**)

INTRODUCTION

Potato is subject to attack by a large number of insect pests among which sap-suckers like the aphids, *Myzus persicae* SULZER and *Aphis gossypii* GLOVER, the leafhoppers, *Amrasca biguttula biguttula* (ISHIDA) and *Empoasca motti* PRUTHI and the whitefly, *Bemisia tabaci* GENNADIUS cause considerable damage to the crop (KUSHWAHA *et al.*, 1976). *Myzus persicae* SULZER is also vector of virus causing diseases like leaf-roll and 'Y'. PATKAR *et al.* (1969) recommended five sprays of oxydemeton methyl and dimethoate at 12 days interval and CHAUDHURI (1974) 2–3 sprays of dimethoate, oxydemeton methyl and phosphamidon for control of potato aphids. SAXENA (1974) found methyl demeton and dimethoate effective for control of the aphids and leafhoppers. SRIVASTAVA *et al.* (1972) found sprays of endosulfan the most effective against the aphids. The present studies were undertaken to evaluate the relative efficacy of six insecticides for the control of aphids, leafhoppers and whiteflies infesting potato in Rajasthan.

MATERIALS AND METHODS

The field experiment was conducted in a randomised block design. The tubers of potato 'S 555' were planted 20 cm apart in 5 metre long furrow spaced at 50 cm distance in each sub-plot measuring 5m×4m. There were six insecticidal treatments (Tables 1–3) besides control, each replicated thrice. Three spray treatments were given at 15 days interval on 66th, 82th and 98th days after transplanting. The efficacy of the treatments was evaluated on the basis of pest population recorded a day before and 1,3,7 and 15 days after each treatment. Three compound leaves, one each from upper, middle and lower portion of each tagged plant were observed and counts of aphids, leafhoppers (both nymph and adults) and whitefly were taken from 11 randomly tagged plants in each replicated plot before 8.0 AM. The pest population data thus obtained were pooled together and subjected to analysis of variance after $\sqrt{n+1}$ transformation (BARTLETT, 1936).

RESULTS AND DISCUSSION

All the insecticidal treatments proved significantly superior over control in reducing the population of aphids, leafhoppers and the whitefly at all the intervals except endosulfan at 15 and 7 days interval against aphids and whitefly and phosphamidon at 3

days interval against leafhoppers (Tables 1–3).

Against aphids, all the insecticides proved equally effective at one day interval, but at 3 days interval, dimethoate and methamidophos were signifacantly superior over the treatments of phosphamidon and endosulfan while methyl demeton and monocrotophos were intermediate in action. The results at 7 and 15 days interval revealed that endosulfan was significantly inferior to all the insecticides except phosphamidon (Table 1). In case of leafhoppers, all the insecticidal treatments showed no significance among themselves at all the intervals however, maximum population was controlled in dimethoate followed by methamidophos and minimnm in endosulfan and phosphamidon (Table 2). All the insecticides were equally effective in checking the population of whitefly at all intervals except at 7 days where endosulfan was least effective and comparable to control. However, both dimethoate and methamidophos proved significantly superior over endosulfan at 3 and 7 days interval but dimethoate alone proved better than endosulfan at 15 days interval (Table 3).

All the insecticidal treatments proved effective for the control of aphids, leafhoppers and whitefly. However, dimethoate 0.03% spray in general proved better than all the other insecticides in checking population of all the three insects. Next to dimethoate, methamidophos 0.1% followed by methyl demeton 0.03% and monocrotophos 0.03% were found to be effective. These results are in agreement with PATKAR

TABLE 1. Efficacy of different insecticides for the control of potato aphids.

Treatments	Concentration (%)	Mean population of aphids				
		pre-treatment	days after treatment			
			1	3	7	15
Dimethoate (Rogor) 30 EC	0.03	36.0 (6.06)	0.67 (1.27)	2.67 (1.91)	23.67 (4.94)	26.33 (5.20)
Methyl demeton (Metasystox)25 EC	0.03	31.33 (5.56)	2.33 (1.74)	4.00 (2.21)	31.67 (5.70)	34.67 (5.77)
Monocrotophos (Azodrin) 40 EC	0.03	21.33 (4.70)	3.33 (2.03)	5.33 (2.46)	33.33 (5.85)	28.33 (5.36)
Phosphamidon (Dimecron) 100 EC	0.03	51.67 (7.11)	4.33 (2.15)	9.33 (3.13)	36.33 (6.03)	71.67 (8.42)
Methamidophos (Tamaron) 60 SC	0.10	11.67 (3.55)	1.33 (1.48)	3.00 (1.96)	28.33 (5.34)	23.33 (4.86)
Endosulfan (Thiodan) 35 EC	0.05	48.67 (6.89)	7.00 (2.70)	9.67 (3.21)	60.67 (7.75)	156.00 (12.17)
Control		51.33 (7.11)	27.67 (5.30)	21.67 (4.71)	92.00 (9.60)	254.33 (15.60)
C D at 5%			(1.46)	(1.15)	(1.81)	(4.19)

Figures in parentheses are $\sqrt{n+1}$ transformation values.

TABLE 2. Efficacy of different insecticides for the control of potato leafhoppers.

Treatments	Concentration (%)	Mean population of leafhoppers				
		pre-treatment	days after treatment			
			1	3	7	15
Dimethoate (Rogor) 30 EC	0.03	4.33 (2.31)	0.67 (1.27)	0.67 (1.27)	0.67 (1.24)	2.33 (1.68)
Methyl demeton (Metasystox) 25 EC	0.03	2.33 (1.74)	1.00 (1.38)	1.67 (1.62)	0.67 (1.27)	3.33 (2.06)
Monocrotophos (Azodrin) 40 EC	0.03	0.67 (1.27)	1.33 (1.51)	1.67 (1.60)	1.00 (1.38)	4.00 (2.16)
Phosphamidon (Dimecron) 100 EC	0.03	3.67 (2.09)	1.67 (1.62)	2.67 (1.81)	2.33 (1.72)	4.00 (2.20)
Methamidophos (Tamaron) 60 SC	0.10	2.67 (1.82)	0.67 (1.24)	1.00 (1.38)	0.67 (1.27)	3.67 (1.96)
Endosulfan (Thiodan) 35 EC	0.05	1.67 (1.61)	1.33 (1.51)	2.33 (1.72)	3.33 (1.99)	4.00 (2.24)
Control	—	7.33 (2.82)	8.33 (3.04)	5.00 (2.39)	8.67 (3.11)	13.00 (3.23)
C D at 5%			(0.48)	(0.61)	(0.83)	(0.59)

Figures in parentheses are $\sqrt{n+1}$ transformation values.

TABLE 3. Efficacy of different insecticides for the control of potato whitefly.

Treatments	Concentration (%)	Mean population of whitefly				
		pre-treatment	days after treatments			
			1	3	7	15
Dimethoate (Rogor) 30 EC	0.03	0.67 (1.27)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)
Methyl demeton (Metasystox) 25 EC	0.03	0.67 (1.24)	0.33 (1.14)	0.33 (1.14)	0.33 (1.14)	0.33 (1.14)
Monocrotophos (Azodrin) 40 EC	0.03	0.0 (1.0)	0.0 (1.0)	0.33 (1.14)	0.0 (1.0)	0.0 (1.0)
Phosphamidon (Dimecron) 100 EC	.03	1.33 (1.48)	0.33 (1.14)	0.67 (1.27)	0.33 (1.14)	0.33 (1.14)
Methamidophos (Tamaron) 60 SC	0.10	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.33 (1.14)
Endosulfan (Thiodan) 35 EC	0.05	0.0 (1.0)	0.33 (1.14)	1.0 (1.41)	2.67 (1.75)	1.0 (1.38)
Control	—	3.0 (1.85)	3.33 (2.06)	2.67 (1.91)	2.67 (1.82)	4.67 (2.21)
CD at 5%			(0.35)	(0.30)	(0.42)	(0.26)

Figures in parentheses are $\sqrt{n+1}$ transformation values.

et al. (1969) who reported 5 sprays of oxydemeton methyl and dimethoate at 12 days interval and CHAUDHURI (1974) suggested 2–3 sprays of dimethoate and oxydemeton methyl for the control of aphids. In the present experiment, 3 sprays of dimethoate (0.03%) at 15 days interval were enough to control the aphids, leaf–hoppers and whitefly. This difference may be due to buildup of insect population in a particular agro–climatic region. SAXENA (1974) also reported dimethoate and methyl demeton spray for the control of aphids and leafhoppers. Contrary to the present findings SRIVASTAVA *et al.* (1972) reported that 0.1% spray of endosulfan was most effective against potato aphids.

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THE PEST STATUS AND BIOLOGY OF *SPILOSTETHUS PANDURUS* (SCOPOLI) (LYGAEIDAE : HETEROPTERA)

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Spilostethus pandurus (SCOP.) **the south Indian milkweed bug is recorded as a pest of gingelly (*Sesamum indicum*) in South India. *Sorghum vulgare* (Poaceae) and *Gossypium hirsutum* (Malvaceae) are also confirmed as host plants of this species. *Vernonia cinerea* (Compositae) and *Hibiscus sabdariffa* (Malvaceae), are reported for the first time as host plants of this polyphagous species. The host plant association of *Spilostethus pandurus* in gingelly field is established as *Calotropis gigantea* (Asclepiadaceae). Host preference, oviposition sites and predators of this species are discussed. Biological data concerning longevity and fecundity are described based on laboratory experiments. The population dynamics of this species for one year on *Calotropis*, the principal host and *Vernonia cinerea* are recorded.**

(*Key words: Spilostethus pandurus*, **pest status, biology**)

INTRODUCTION

Incidence of *Spilostethus pandurus* has been known on *Calotropis* (FLETCHER, 1921; MISRA, 1924), Cotton (MAXWELL-LEFROY, 1909 a, b) MISRA (1924), HARGREAVES (1948), BHATTACHERJEE (1959), sorghum, redgram and chillies (FLETCHER, 1914, 1921), grapevine and citrus (ISAAC, 1946) and peach and mango (AHMAD, 1946). The present investigations report the incidence of *S. pandurus* as a pest of *Sesamum* and attempts have been made to study the host preference and bio-ecological aspects.

MATERIALS AND METHODS

The degree of infestation of *S. pandurus* was studied by weekly collections on *Calotropis gigantea*, and gingelly. The population counts were made from five plants of each. Host preference and oviposition sites were mainly observed in the field and was supplemented with laboratory studies in which various parts of the host plants were randomly arranged in a spacious glass trough and exposed to a large number of one-day-starved adults and nymphal instars of all stages collected from the fields. The glass trough was covered with muslin cloth and kept undisturbed for five days. Every hour the number of individuals feeding on different parts of various host plants and mating and oviposition by adults were noted. These experiments were conducted at room temperature during the period March to May and repeated during August to November 1975. The maximum and minimum temperature (°C) and relative humidity (%) ranged between 32.8°C; 37.8°C; 22.6°C—27.7°C and 65%—68%; 58%—69% during March to May and the same variables ranged from 24.6°C—35.9°C; 20.5°C—25.5°C and 64%—96% and 58%—90% respectively during August to November. Population of the bug was recorded for one year from February, 1975 to January 1976 on *Calotropis* and *Vernonia* growing on field bunds.

OBSERVATIONS AND DISCUSSION

Recently a severe infestation of the South Indian milkweed bug was noticed on gingelly at Madras and subsequently recorded at Salem and Tindivanam especially wherever *Calotropis* grows wild in large number. The infestation occurs just prior to flowering in gingelly. In severely infested fields, the entire leaves of the plant withers completely forming curled rolls, and early attack of

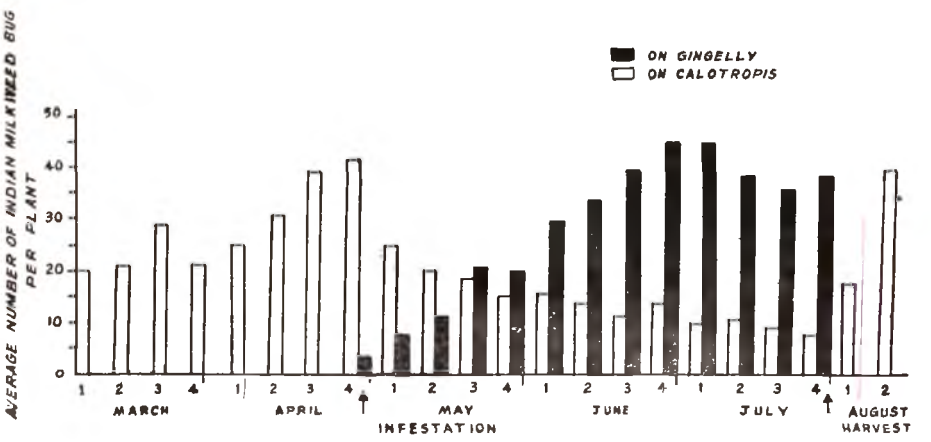

Fig. 1. Infestation trend of the milkweed bug from *Calotropis* to gingelly

nymphs on young gingelly plant results in abnormally small leaves with stunted growth and a few capsules of smaller contour with several malformations and seeds poorly developed inside the pods; in still acute infestation the pods dry and wither prematurely. Weekly population counts (Fig. 1) show that after infestation on gingelly, the population of *S. pandurus* shoots up steadily until just before the harvest of the crop. After harvest, the adults fly back to their principal host, *Calotropis*. Fourth and fifth nymphal intars were observed to migrate through the grass bunds. On one severely infested gingelly plant eight adult and seventy five nymphs were observed feeding. In the gingelly field always the nymphal population was greater than adult population (Fig. 2) and the nymphs cause considerable damage to gingelly than adults. There was considerable mortality during first, fourth and fifth instar stages. When the milkweed bug population was at its peak on gingelly, the common crow, *Corvus splendens* was found to feed on these bugs, which substantially reduced the nymphal population. *Calotropis* and *Vernonia* may serve as reservoirs and alternate host plants. Removal of these weeds before cultivation may reduce the incidence of this bug on cultivated crops.

Gingelly is an important oil seed crop, widely cultivated in South India as a summer crop and the only lygaeid pest recorded on *Sesamum* is *Nysius inconspicuus* DISTANT, which sucks the sap of tender parts of growing gingelly (RAMAKRISHNA AYER, 1938; THANGAVELU, 1978 b). The occurrence of *S. pandurus* on gingelly is therefore recorded

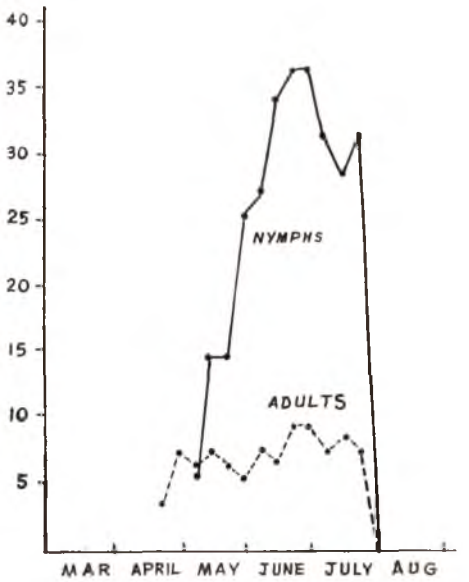

Fig. 2. Adult and nymphal population frequency on gingelly.

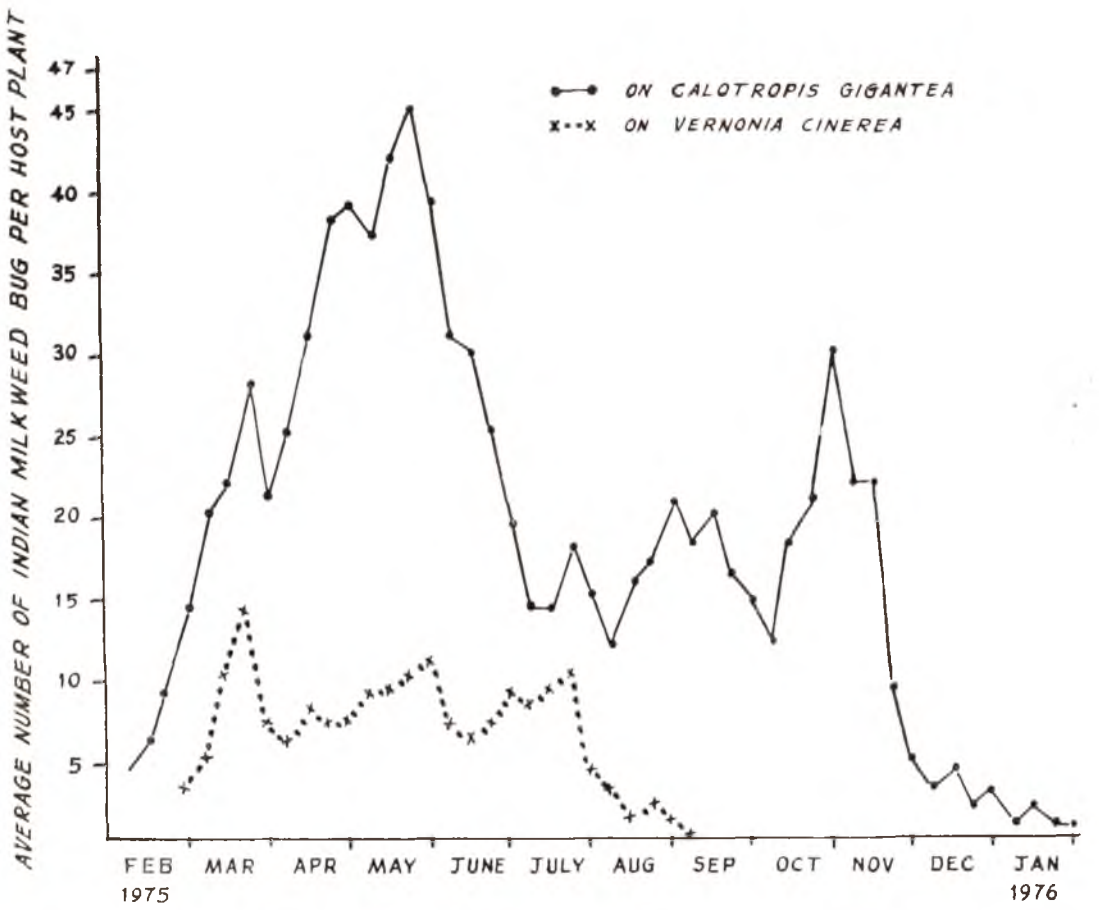

Fig. 3. Annual population trend of the mlikweed bug on *Calotropis* and *Vernonia*.

for the first time and the bio-ecological investigations are reported here.

Life cycle

The life cycle extends over a period of 25–30 days in summer and 29–45 days in winter, and the adults live about a month in summer; in a few cases it was found that adults live 23–45 days in winter. An adult female lays 45–90 eggs, in exceptional cases 119 and 130 eggs. BHATTACHERJEE (1959) while studying the bio-ecology of *Lygaeus pandurus* (SCOP.) recorded 50–60 eggs normally and as many as 90 eggs; this increased fecundity in South India may be attributed to the more warm climate. The population studies (Fig. 3) reveal that the milkweed bug lives and reproduces throughout the year with 6 to 7 life cycles with one or more overlapping generation.

Host range

The milkweed bug has been earlier reported on cotton, sorghum, redgram, chillies, grapevine, *(Solanum melongena)*, tomato *(Lycopersicum esculentum)*, bean (*Vicia faba)* lady's finger *(Hibiscus esculentus)*, *Psidium guava* and *Ficus* spp. Yet all these may not be true host plants and the latter records

may be mere "sitting records" or "occasional feeding" by the adult. However as the milkweed bug has been repeatedly reported by several investigators in various parts of India on these economically important crops, it may become a noxious potential pest. During this study at Tindivanam (South India), the adult bugs were found feeding on the country bean, *Cyamopsis tetragonalobs* in large numbers. Thus it appears to be polyphagous in its host range.

Population fluctuation

The population dynamics of this bug was studied for one year on *Calotropis*, a perennial and noxious weed and *Vernonia cinerea* (Fig. 3), another common weed in the fields and dry waste land. The bug is active and abundant during hotter summer months (March–June) and then during October. In the colder months (January–February and November–December) the bug is scarce. The weed *Vernonia* is common only during the summer period between February and August, during rest of the season its growth is only sporadic and therefore the milkweed bug inhabits it in less numbers; the population of the milkweed bug on *Vernonia* dwindles and disappears during winter months and reappears on *Vernonia* when the weed sprouts again during subsequent summer. During one gingelly crop (March–August, 1975) it was observed that the milkweed bug infests the gingelly from *Calotropis* and the pest population builds up steadily on gingelly; an average of 45 bugs was recorded, which ranged from 18–83. This is an unusual build up of population for the month of July, otherwise only during March-May these bugs are abundant (Fig. 3). This unusual abundance may be attributed to the greater availability of food and breeding site in the gingelly field. During late July, the slight decline of the milkweed bug on gingelly is mainly due to the predation of *Corvus splendens* in addition to the predatory spiders preying on the nymphs of this bug. From late November to early February there are considerably few in resting conditions in places of high altitude like Yercaud (4824′), Kodaikanal (7000′), Bangalore (4559′), Brindavan (Mysore) (3489′) where the bugs were seen resting motionless under fallen dry fig leaves, grass and forest litter. While resting, when disturbed, they did not move away quickly or fly as they do in summer months; dissection of such resting individuals showed degenerated ovary and less fat bodies. Most often it is the adult which survives through severe winter season.

Host preference for feeding

Host preference shows that adult bugs exhibit preferential feeding on the seeds while the nymphs on leaves, inflorescence and tender seeds of *Calotropis* sp., *Sesamum indicum*, *Gossypium hirsutum*., *G. barbadense*, *Hibiscus sabdariffa*, *Vernonia cinerea*, *Sorghum vulgare* and the other host plants are less frequented.

Host preference for oviposition

Preference for oviposition site differs from feeding preference under laboratory condition. More egg clusters are laid on the dry capsules of *Hibiscus sabdariffa*, between the capsular wall and outer dry inflorescence of *Vernonia* is less preferred and the other capsules still less preferred. This exercised choice reveal, that capsules of *H. sabdariffa* and dry inflorescence of *Vernonia* afford more sheltered area for protection. This bug exhibits subsocial behaviour such as aggregation and pseudoparental care by selecting oviposition sites and laying clusters of eggs. The adult females lay egg clusters of nine, six, five and three and less frequently single eggs on the loose soil around the stem base. Subsequently, the just emerged nymphs feed on the bases of the stem and slowly crawl along the stem

and climb up and spread through the entire plant.

Feeding habits

The adult bugs usually feed on the pods of gingelly, occasionally feed on the leaves and the inflorescence. All the nymphs voraciously feed on various part of the plant including tender pods, but largely feed on the under surfaces and bases of the leaves especially first three instars feed in groups and at times more than twenty nymphs have been observed in one feeding congregation. Gregarious feeding nature and voracious feeding habit cause considerable loss of sap, resulting in wilting and drying up of leaves. Though the feeding of the bug does not seem to transmit any disease, the feeding sites become more vulnerable to pathogens attack.

Effect of overcrowding

It is well known that longevity varied with different food and temperature, yet nothing is known about the effects of overcrowding and aggregation which are yet to be clearly understood, as BHATTACHERJEE (1959) has reported cannibalistic habit from third instar onwards in *Lygaeus pandurus* (SCOPE.). In this study, it was noted that survival rate of adults were appreciably reduced and greater mortality among first instars due to overcrowding. FEIR (1963) similarly reported in *Oncopeltus fasciatus* (Dallas). In overcrowded insectaries mating pairs were frequently intruded by other adults and that decreased successful mating, in these bugs a successful mating, required atleast 2–6 hours in copula position (THANGAVELU, 1978 a). Overcrowding inhibits oviposition, as females reared in overcrowded insectaries laid fewer eggs and oviposition period was reduced.

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EXTERNAL MORPHOLOGY OF THE HEAD CAPSULE OF *SPHYRACEPHALA HEARSEIANA* WESTWOOD (DIOPSIDAE : DIPTERA)[1]

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(Received 16 January 1978)

The head of *Sphyracephala hearseiana* is typically hypognathous with mouth parts hanging down from the oral margin at 90° with the body axis. The head capsule is laterally extended to form eye stalks bearing a pair of dichoptic compound eyes. There is a distinct wide ptilinum in front of a shallow 'U', the arm of which extends into the extended eye-stalks, dividing the frons into a postfrons and prefrons. Three sulci, the frontal sulcus, the ptilinal sulcus both in the anterior region and the post-occipital sulcus in the posterior region are prominent on the cranium. The vertical region bears a sclerotized slightly raised-up ocellar triangle with a median and two lateral ocelli. A pair of well developed occipital condyles are present for the articulation with the cervical sclerites. The absence of the occipital sulcus converts the whole posterior region into a complex area, occipito-postgenal hypostomal area bearing the occipital foramen in the middle. The tentorium is very much modified. A pair of antennae are seen on the extended eye stalks below the level of the lateral arms of the pitilinal sulcus. The antennae are aristate with three segments.

(*Key words: Sphyracephala hearseiana*, **external morphology of head capsule**)

INTRODUCTION

Many workers have studied the morphology of head of dipterous flies. They include WESCH (1908), PETERSON (1916), IMMS (1920), FREW (1923), JOBLING (1926), SNODGRASS (1928), ATKINS (1949), NAYAR (1961, 1962, 1965), SUTCLIFFE & SUSAN (1974) and CHASSAGNARD & LEONIDAS (1974). The present paper deals with the detailed morphology of the head capsule of *Sphyracephala hearseiana* WESTW.

MATERIALS AND METHODS

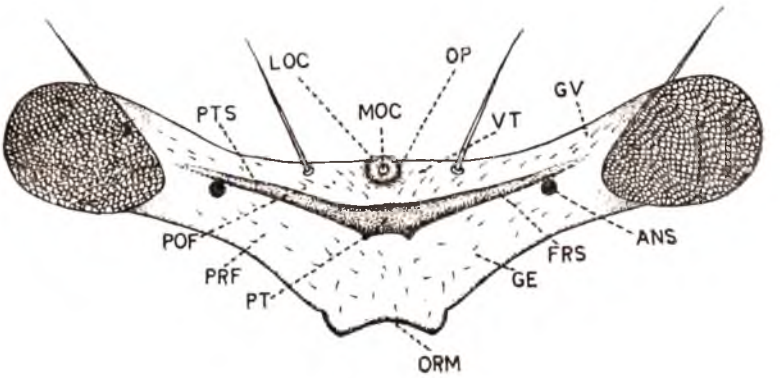
The flies for the work, collected from the damp and shady places, during the months of November and December, were treated with 5 per cent KOH for 30 minutes and then kept overnight in the same solution. Stained and unstained permanent mounts were prepared after the removal of the alkaline effect of the KOH by washing them in glacial acetic acid. The diagrams were drawn with the help of camera lucida.

OBSERVATIONS AND DISCUSSION

The head of *Sphyracephala hearseiana* WESTWOOD is a compact capsule, movably articulated with the thorax through the cervical sclerites which form the lateral walls of the neck. The head (Figs. 1, 2) is produced antero-laterally into long eye stalks measuring about 0·73 mm long and 0·34 mm wide bearing the compound eyes terminally and the antennae, basal to the eyes. It is a typically hypognathus head with mouth parts hanging down from the oral margin at an angle of 90° with the body axis.

The dorsal surface of the head, the region between the eye stalks, is convex while the posterior surface of the head is more or less

[1] Contribution No. 247 from School of Entomology, St. John's College, Agra, India 282002.



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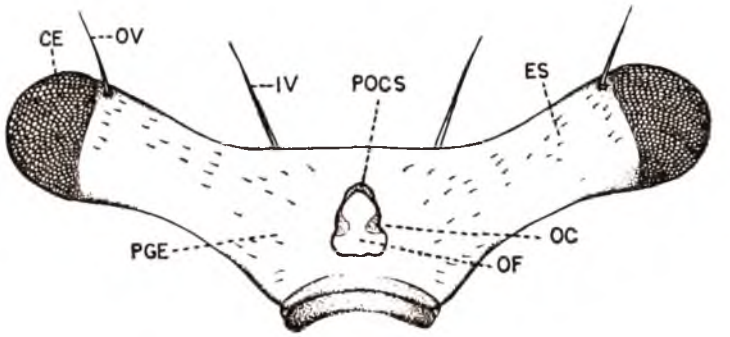

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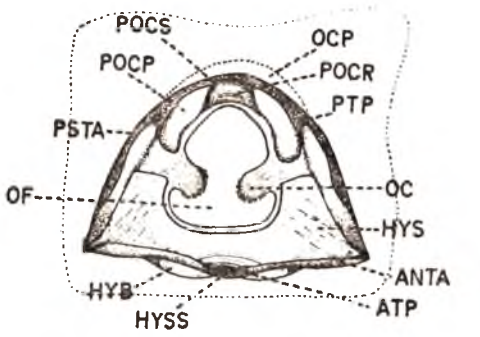
Fig. 1. Anterior view of the head capsule. Fig. 2. Posterior view of the head capsule.

straight. The width of the head from eye to eye is about 2·10 mm in male and 2·22 mm in female. The head region and the sulci have undergone a great deal of modification mainly as a result of the formation of the eye stalks.

Three sulci are very prominent on the cranium of *Sphyracephala hearseiana*, *viz*, frontal sulcus (Fig. 1) and ptilinal sulcus in the anterior region, the postoccipital sulcus (Figs. 2, 3) in the posterior region. The areas distinguishable are prefrons, postfrons and the genovertical areas in the frontal region and the postgena, occipitovertical region, postgenal-hypostomal bridge and postocciput in the occipital region. The area ventral to the compound eye upto the subcranial fossa represent the gena and behind the compound eyes upto the postoccipital sulcus as the postgena. There are two pairs of strong bristles, inner verticals outer to the ocellar plate, and outer verticals just inner to the compound eyes.

Anterior region : The anterior or facial region of the cranium, bounded laterally by



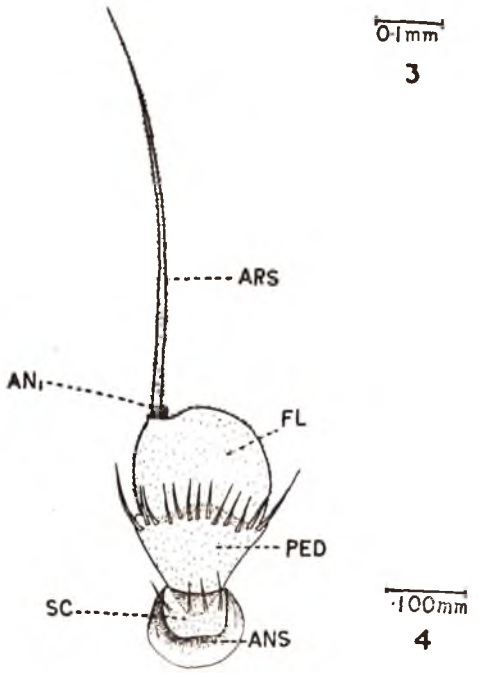


Fig. 3. Inner aspect of the posterior region of head with tentorium. Fig. 4. Antenna.

the stalked compound eye (Fig. 1), ventrally by the oral fossa and dorsally by the anterior margin of the vertex, demarcated by the vertical bristles and anterior extension of the ocellar triangle is generally designated as the frontal region. Below the vertex on the anterior side the whole area stretching in between the compound eyes represents the frons, which is divided into the postfrons and prefrons by the presence of ptilinum. The ptilinum when viewed from front is in the form of a shallow 'U', the arms of which extending more than half the length of the extended eye stalk, just over the bases of the antennae. The ptilinum is demarcated anteriorly by the frontal sulcus and posteriorly by the ptilinal sulcus. The prefrons stretches from the ptilinal sulcus to the oral fossa, while the region above the sulcus upto the vortex forms the postfrons. The prefrons bears a pair of antennae far apart from each other just below the extending lateral limbs of ptilinal sulcus.

The formation of the eye stalks by the lateral extension of the head capsule and the consequent wide separation of the antennal fossae is an interesting phenomenon. As a consequence of this, the ptilinum itself is outstretched. The lateral extension of the ptilinum appearing as a dark streak across the lower part of the postfrons was termed as 'arcuate line' was wrongly homologised with lunule by many workers (SHILLITO, 1971). The fusion of the frontal

ABBREVIATIONS USED

AN1—First annulus; AN2—Second annulus; ANS—Antennal socket; ANTA—Anterior tentorial arm; ARS—Arista; ATP—Anterior tentorial pit; CE—Compound eye; ES—Eye stalk; FL—Flagellum; FRS—Frontal sulcus; GE—Cena; GV—Cenovertical area; HYB—Hypostomal bridge; HYS—Hypostome; HYSS—Hypostomal sulcus; IV—Inner vertical; LOC—Lateral ocellus; MOC—Median ocellus; OC—Occipital condyle; OF—Occipital foramen; OCP—Occiput; OP—Ocellar plate; ORM—Oral rim; OV—Outer vertical bristle; PED—Pedicel; PGE—Post gena; POCP—Postocciput; POCR—Post occital ridge; POCS—Post occipital sulcus; POF—Post-frons; PRF—Pre-frons; PSTA—Posterior tentorial arm; PT—Ptilinum; PTP—Posterior tentorial pit; PTS—Ptilinal sulcucs; SC—Scape; VT—Vertex.

and ptilinal sulcus laterally and its extension to the base of the eye, a condition observed by DESCAMPS (1957) in Diopsids is not found in this fly. The extension in Diopsids forms a sulcus "Stielfurche" giving additional support and rigidity to eye stalks. Such a condition is not observed in *Sphyracephala hearseiana* as here the frontal sulcus and ptilinal sulcus remain separate. A facial sulcus formed by the anterior extension of the frontal sulcus on to the oral rim dividing the prefrons medially into two, reported in *Diopsis thoracisa* WESTWOOD by SHILLITO (1971) is absent in the case of *S. hearseiana* Westwood. The vertex bears a sclerotised slightly raised up ocellar triangle with median and two lateral ocelli. The base of the triangular ocellar plate measures about 0.12 mm in width and 0.08 mm in length. The cylindrical 'eye stalks' are probably constituted by the lateral extensions of the frons and vertex.

Posterior region : The posterior surface of the head capsule (Fig. 3) bears the occipital foramen and is bounded by occipital rim which is fused with the post occipital sulcus dorso-laterally. The area of the occipital foramen measures about 0.24 mm in width. Internally the fusion product of the post-occipital sulcus and the occipital rim forms a very well developed postoccipital ridge forming a broad apodemal plate laterally. The occipital condyles, the sclerotised articulation surface for the cervical sclerites are well developed and project into the occipital foramen from the lateral sides. The space between the two condyles measures about 0.08 mm. Internally on the dorsal side there is present a distinct ridge marking the position of occipital sulcus. The area between the postoccipital sulcus and this ridge may well be considered representing the occiput. The absence of occipital sulcus converts the whole posterior region into a complex area occipito-postgenal hypostomal area bearing the occipital foramen in the middle. The ventral border of the occipital foramen is constituted by the transverse hypostomal bridge measuring about 0.48 mm. The anterior tentorial pits are seen demarcating the hypostomal bridge and the postgenal bridge area.

Tentorium : The tentorium is the endoskeleton or internal cuticular frame work of the head capsule formed by the inflections of the cranial walls and union of apodemal arms from the exoskeleton. The tentorium (Fig. 3) is very much modified in case of *S. hearseiana* WESTWOOD. The anterior tentorial arms lie in a more or less lateral position. Their inner anterior arms fuse with the hypostomal postgenal complex at the anterior tentorial pit indicating their boundary limits. Laterally they fuse with the anterior tips of the posterior arms at an angle of 60°. The posterior tentorial pits are seen dorsolateral to the occipital condyles. Arms arising from the posterior tentorial pits, the posterior tentorial arms extend anteriorly directed away from the occipital foramen and fuse with the extensions of the anterior tentorial arms on either side. The dorsal posterior extensions of the posteior arms run dorsally and fuse with the upper edge of the postoccipital ridge. Thus the modified tentorium of this fly forms a complete brace work around the occipital foramen giving additional strength and support to the sclerites and surface for attachment of muscles. Such a condition of the tentorium is not reported so far in allied Diptera. NAYAR (1962) reported in the same fly, a reduced corporotentorium with only posterior tentorial arms. It is apparent that he failed to observe the real posterior tentorial arms and considered the anterior arms as the posterior one. He also failed to locate the posterior tentorial pits, and also the anterior tentorial pit.

It is interesting to note here that the anterior tentorial pit is withdrawn from the oral margin and so is the posterior tentorial pits which are dorsolateral to the occipital condyles in this fly. In most cases the tentorium is a product of the fusion of the four internal apodemal arms of the exoskeleton. SNODGRASS (1935) considered the pterygote tentorium as a composite structure formed of tergal and sternal elements.

Appendages of the head : The appendages of the head comprise a pair of antennae and the mouth parts in the form of pendulous proboscis.

Aetenna : A pair of antennae (Fig. 4) are closely inserted on the extended eye stalks closer to the base of the compound eye and below the ptilinal sulcus. The antennae are brown, pubescent and three segmented. The base of the antenna is movably articulated to the antennal socket. The first segment of antenna which is attached to the head in an antennal socket is the scape, second pedicel and third is the flagellum. The antenna along with its arista measures about 1.02 mm in length. The scape or basal segment is smallest, cylindrical almost equally wide both basally and apically. It measures about 0.01 mm in length and 0.08 mm in width. It bears four bristles subterminally. The second antennal segment or pedicel, measures about 0.10 mm longer than scape, narrow basally and broad apically with the distal and nearly three times as broad as base, bearing a row of thirteen prominent bristles subapically. The third antennal segment or flagellum (measuring about 0.14 mm in length and 0.16 mm wide) is nearly as long as wide two segmented dorsal arista arising subapically. All the segments of antenna are clothed with dense, minute pubescence.

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COMPARATIVE MORPHOLOGY OF GALEA AND LACINIA IN HYMENOPTERA

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In Xyelidae the galea is a bilobed structure and less prominent than the lacinia. In Pamphiliidae, Cimbicidae, Tenthredinidae, Diprionidae, Cephidae and Xiphydridae both these lobes are equally developed. However, in Argidae the case is different where the lacinia is secondarily reduced. This development is stretched further in Siricidae where the lacinia is altogether absent, while the galea is prominently represented. This condition may be attributed to the state of fusion of the maxilla with the labium along its mesal margin thereby obliterating the mesal lobe altogether. Among Apocrita the ichneumonids form the basis of one line of transformations of these lobes where galea is slightly more developed than the lacinia. This state is well represented in the various families of Apocrita like Chyrsididae, Mutillidae and Formicidae. Chalcids form the basis of another line of transformations represented by the other families of Apocrita, like Scoliidae, Sphecidae, Vespidae, Eumenidae and Pompilidae, where galea is progressively more developed while the lacinial size getting diminished till ultimately in Xylocopidae and Bombidae it is only scale like and is on the verge of becoming almost obliterated. In the honey bee, however, the lacinia has already become totally absent. These observations on the transformation of these two lobes establish definite phylogenetic relationship among the various families of this insect order.

(*Key words:* **galea, lacinia, comparative morphology, Hymenoptera**)

INTRODUCTION

No work is available concerning the phylogenetic history of the gradual reduction in the size of the lacinia leading to its ultimate disappearance. These changes in the lacinia, are accompanied by changes in the form of galea but in the reverse order. This gradually increases in size. Not that these two terminal lobes of maxilla did not attract attention of the morphologists. Many works are available on them which deal with their structure from an ontological angle. VAN DINE (1905), Crampton (1923), SNODGRASS (1925, 1935), RIVARD (1955), MATSUDA (1957, 1965), BRACKEN (1961), TAIT (1962), WONG (1963), DHILLON (1966) GOTWAID (1969), KHALIL & HABIB (1969), have abundantly referred to these maxillary lobes. The present study is an attempt to trace the systematic pattern of changes in these lobes to ultimately achieve among Apocrita the structures which are far removed from their basic form occurring in Symphyta. Consequently this study will also be of some assistance to establish the phylogenetic relations among the various families of this order, which incidentally also reveal an evolutionary trend.

MATERIALS AND METHODS

To carry on the present study almost all the hymenopterans representing all the superfamilies of suborder Apocrita, were collected from the Punjab and Himachal Pradesh during the months of September and October (1975) and the material so collected was preserved in 80% alcohol. However, the representatives of the various families of suborder Symphyta with the exception of Megalodontidae and Orussidae, were supplied by the Biosystematic Research Institute, Canada, and Zoological

Survey of India. The specimens provided by them were in a dry state, which were softened after keeping them in 2% KOH for about six hours. Pigmented specimens were bleached with 0.5% KOH after keeping them in the latter for about 6 days. Diagrams were drawn with the help of graph eyepiece.

OBSERVATIONS AND DISCUSSION

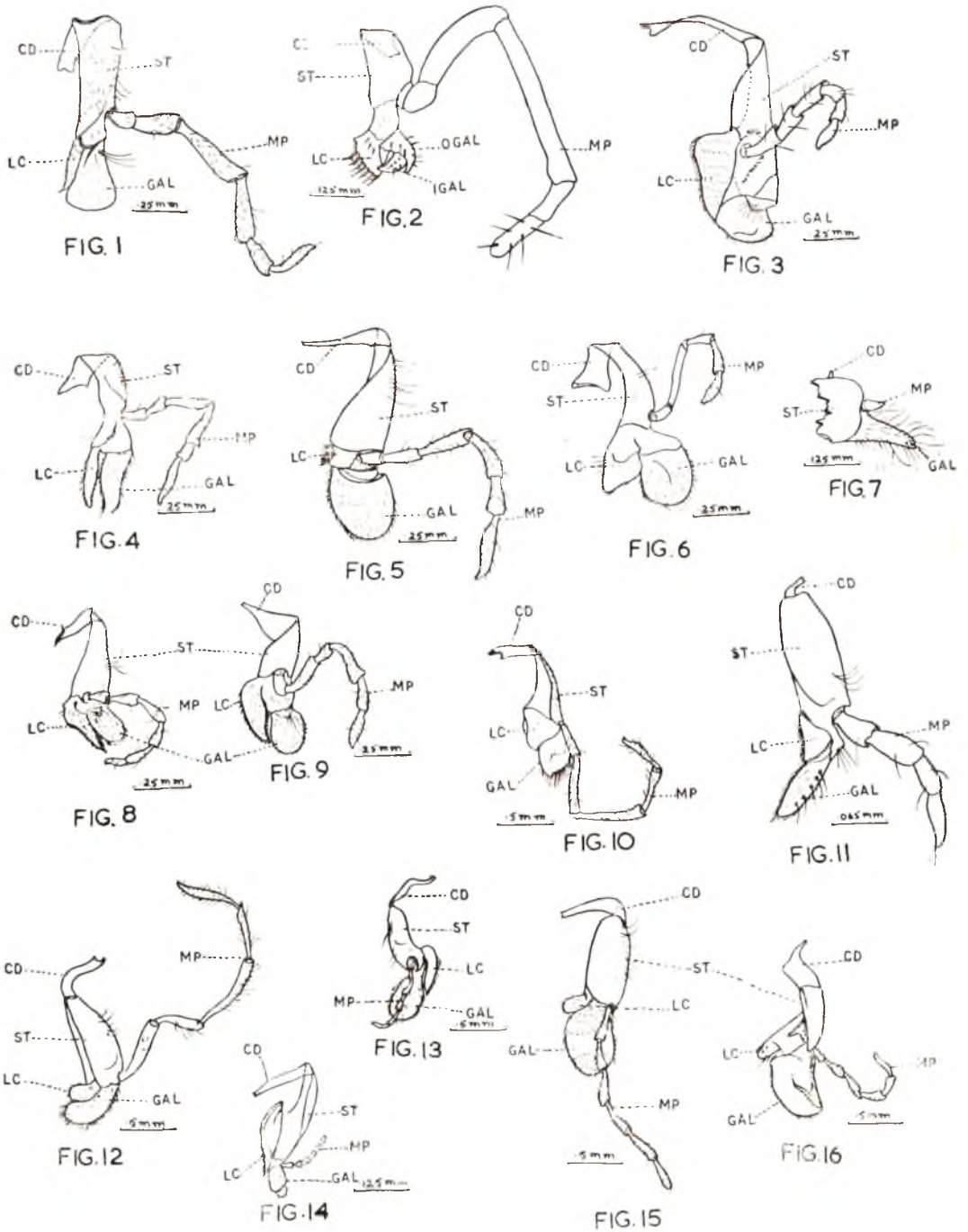
In the generalized symphytans the galea is small while the lacinia is quite conspicuous in the form of a dominating distal lobe of the maxilla. This condition is just the reverse in higher apocritans. Here the lacinia is inconspicuous, almost scale like which may be even absent, whereas, the galea is a highly developed structure. However, in some symphytans as well as apocritans the size and form of these two distal lobes of the maxilla are intermediate between the above mentioned two extremes. The systematic study of all these forms reveal an orthogenic sequence of evolutionary transformations, the coherent account of which has been given below.

The most primitive condition in this regard is found in *Xyela bakeri* (Fig. 2) (Xyelidae). In this case lacinia is prominent, bearing a row of very stiff setae all along its distal margin which imparts it a comb shaped appearance. The galea is a bilobed structure and both the lobes are provided with some scattered stiff setae. Similar bilobed galea has also been reported by CRAMPTON (1923) in *Xyela* sp. and *Macroxyela* sp. and ARORA (1956) in *Xyela julii*.

In most of the other symphytans such as in *Acantholyda maculiventris* (Fig. 1) (Pampiliidae), *Cimbex americana americana* (Fig. 3) (Cimbicidae), *Pristiphora cincta* (Fig. 9) (Tenthredinidae), *Neodiprion abietis* (Fig. 8) (Diprionidae), *Cephus* (*Cephus*) *cinctus* (Fig. 4) (cephidae) and *Xiphydria mellipes* (Fig. 5) (Xiphydridae), the galea and lacinia are quite developed. However, their shapes and sizes may vary in different families. In *Neodiprion*, *Pristiphora*, *Cimbex* and *Acantholyda*, lacinia is a triangular structure possessing a distal pointed end. Its lateral margins are serrated and bear a rich growth of small sensory setae. Its dorsal and ventral surfaces are also beset with a scattered growth of setae. In all these cases the galea is a club–shaped structure which is rounded distally. Its ventral and dorsal surfaces are provided with scattered setae.

In *Cephus* the lacinia is an elongated and distally pointed structure and it is covered over by the scattered setae, whereas galea is a triangular lobe also covered over by setae which are more prominent along its lateral margins. In *Xiphydria* the lacinia is an irregular structure, whereas, the galea is a clubshaped rounded lobe bearing the long setae. Similar observations have also been made on *Pachyprotasis versicolor*, *Pachyprotasis brunetti* and *Tomestethus (Eutomostethus) assomensis* (Tenthredinidae) and *Zarae inflata* (Cimbicidae). These findings are further substantiated by the similar studies of VANDINE (1905), CRAMPTON (1923), SNODGRASS (1925, 1935), BIRD (1926), ROSS (1937), REEKS (1937), ARORA (1953, 1956), RIVARD (1955), MATSUDA (1957, 1965), BRACKEN (1961), WONG (1963), IMMS (1963), DHILLON (1966). However, in *Arge clavicornis* (Fig. 5) (Argidae), the lacinia is sufficiently reduced which seems to be a secondary modification. ARORA (1956) has also observed a very reduced lacinia in *Arge ochropus* (Argidae).

Differently modified conditions occur in *Sirex cyaneus* (Fig. 7) (Siricidae). In this case the entire mesal margin of each maxilla is completely fused with the labium, and on this account the lacinia has lost its independent identity. However, its outer lobe, the galea (Fig. 7) is quite prominent and it bears a rich growth of long setae. Similar observations have also been made



Lateral view of the maxilla of: 1. *Acantholyda maculiventris;* 2. *Xyela bakeri;* 3. *Cimbex americana americana;* 4. *Cephus (Cephus) cinctus;* 5. *Arge clavicornis;* 6. *Xiphydria mellipes;* 7. *Sirex cyaneus;* 8. *Neodiprion abietis;* 9. *Pristiphora cincta;* 10. *Netelia kashmirensis;* 11. *Sycoscapter stabilis;* 12. *Trachystaphyrus* sp.; 13. *Chrysis indogolea;* 14. *Scolia quadripustulata;* 15. *Scelephron intrudens;* 16. *Stizus vespiformis*

by Ross (1948) in case of *Tremex calumba* (Siricidae). ARORA (1956) in *Urocerus gigas* (Siricidae) and TAIT (1962) in *Perga affinis affinis* (Pergidae). In the latter, the fusion of maxilla with the labium is not complete, and this stage can be taken as intermediate between the siricids and rest of the symphytans.

In the representatives of the Hymenoptera-Parasitica is manifested a further modified form of the galea and the lacinia. In *Sycoscapter stabilis* (Fig. 11) (Chalcidoidea–Torymidae), the lacinia is a small and triangular lobe which is completely dominated by a elongated galea. The mesal margin of the lacinia is provided with a rich growth of long setae. The galea is entirely covered with scattered growth of long and short setae. Similar observations have also been made on some other chalcids like *Blastophaga masoni* (Agaonidae), *Walkerella temeraria* (Torymidae) and *Sycophila decatomoides* (Eurytomidae).

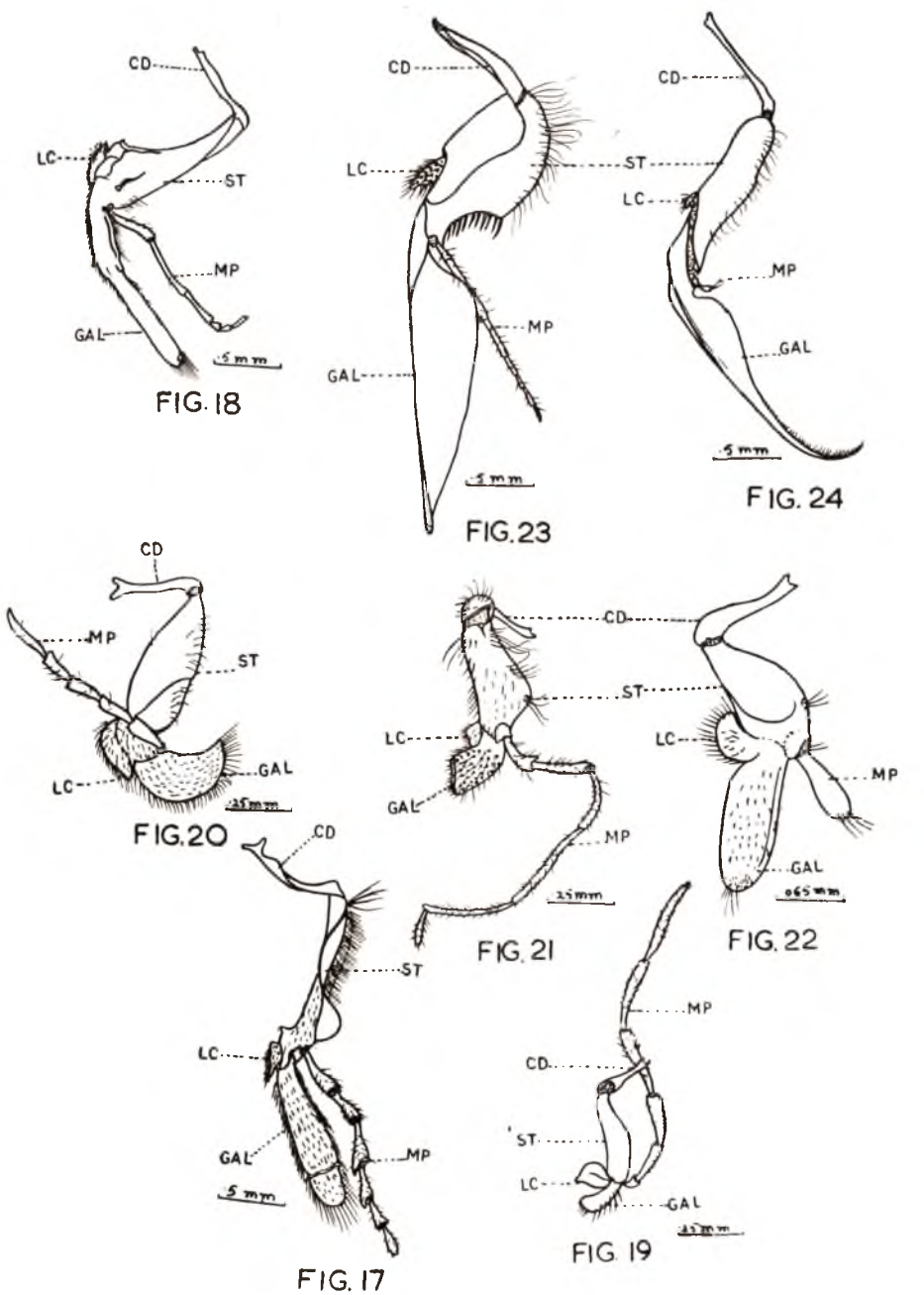
In the representatives of superfamily Ichneumonoidea such as in *Netelia kashmirensis* (Fig. 10) and *Trachysphyrus* sp. (Fig. 12) the galea is only slightly bigger than the lacinia while both are covered over by setae. In the latter insect both the lobes are distally bent inwards and are rounded at their tips, whereas, in the former, both of them taper distally. ALAM (1951) has shown in *Stenobracon deesae* (Braconidae) that the galea is somewhat more prominent than lacinia.

This stage represented by Chalcidoidea and Ichneumonoidea forms the basis of two lines of modifications, one followed by the representatives of the families of Chrysididae, Mutillidae, and Formicidae through ichneumonids and the other followed by the families of Scoliidae, Vespidae, Eumenidae and Apidae through chalcids.

As observed in *Mutilla* sp. (Fig. 19) (Mutillidae), *Chrysis indogolea* (Fig. 13) (Chrysididae), *Sima rufonigra* (Fig. 20), *Camponotus camelinus* (Fig. 21) and *Dorylus labiatus* (Fig. 22) (Formicidae) the structure of galea and lacinia though vary in all of them but they have one thing in common. In all of them the galea and lacinia are almost equally prominent, excepting in *Dorylus labiatus* and *Mutilla* sp. where galea is more pronounced than the lacinia. Similar observations have also been made by GOTWALD (1969) in the different formicids.

The other line of modifications brings the galea in more prominence than the lacinia which in contrast becomes reduced in size till in some of the representatives of the superfamily Apoidea, its presence is hardly noticeable. In *Scolia quadripustulata* (Fig. 14) (Scoliidae). *Scelephron intrudens* (Fig. 15) and *Stizus vespiformis* (Fig. 16) (Sphecidae), the lacinia is small. It is triangular in case of scoliids, while club–shaped in case of sphecids. In both these cases the lacinia is provided with a scattered growth of setae which are more longer and prominent on its mesal margin. The galea in them, is a highly developed lobe of maxilla whose shape varies from species to species being a distally round structure in *Scolia* and *Scelephron* and almost triangular in *Stizus vespiformis*. Similar observations have also been made on *Scolia fulvifrons* and *Elis* sp. (Scoliidae) and *Scelephron violaceum* (Sphecidae).

In *Vespa orientalis* (Fig. 17) (Vespidae) and *Eumenes dimidiatepennis* (Fig. 18) (Eumenidae), the lacinia is inconspicuous being roughly triangular in outline and being moderately sclerotized. It is only identifiable because of its position with respect of the galea. As usual it is thickly covered over with small setae. The galea in these insects is an elongated, moderately



17. *Vespa orientalis;* 18. *Eumenes dimidiatepennis;* 19. *Mutilla* sp., 20. *Sima rufonigra;* 21. *Componotus camelinus;* 22. *Dorylus labiatus;* 23. *Xylocopa lemuiscapa;* 24. *Bombus* sp.

ABBREVIATIONS

CD—Cardo; ST—Stipes; LC—Lacinia; Gal—Galea; MP—Maxillary plap; OGAL—Outer galea; IGAL—Inner galea.

sclerotized structure, which is entirely covered over by a rich growth of setae. The setae are comparatively longer close to its distal tip. Similar observations have also been made by KHALIL & HABIB (1969).

Further modifications are observed in the representatives of the superfamily Apoidea, with respect of galea and lacinia. In *Xylocopa lemuiscapa* (Fig. 23). the lacinia is a small bean shaped semisclerotized structure which is densely covered over with long but slightly stiff setae. The galea, on the other hand is an elongated, highly sclerotized lobe, which completely dominates all the substructures of the maxillolabial complex. In *Bombus* sp. (Fig. 24) the lacinia is reduced further, and it is quite inconspicuous and difficult to make out its presence through a casual observation. It bears only three or four small setae and its relative position with respect to the galea remains unchanged. SNODGRASS (1925, 1935) has reported a complete absence of lacinia in *Andrena carlini* and the honeybee. Where it ought to have been present, that area is represented by a membranous and fluffy area in these bees. However, its disappearance from the place in the honeybee and others can be easily proved on the basis of the muscles which are shown to be retained (MATSUDA, 1965).

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DIURNAL RHYTHM OF SETTLING OF APHIDS (APHIDIDAE : HOMOPTERA) AT KALIMPONG, WEST BENGAL

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The record of alate aphids trapped at the interval of two hours from morning to evening in yellow pan water trap during the major period of alate activity of the year revealed distinct periodicity of their settling. During December-January, the cooler months of the year, there occurred only one peak of settling of air borne aphids between 10 AM and 12 noon, during relatively warm period of March–April two peaks were recorded once in the forenoon and another in the afternoon and during the still warmer period of late April and May there was only one peak of settling activity of air borne aphids but it was in the afternoon.

INTRODUCTION

Insect flight is controlled by various factors like the period of adult emergence, teneral period and the meteorological conditions like intensity of light, temperature, relative humidity, rainfall, wind speed etc. Aerial activity of aphids is also influenced by the aforesaid factors but these are passive fliers and their spatial dispersal is mainly accomplished by the drift in wind current. Active and directed flight of aphid is mostly restricted to the boundary layer horizon of vertical profile of air and this is mostly restricted upto 1.2m from the ground level (TAYLOR, 1974). EASTOP (1951) worked out the diurnal variation of aerial density of aphids in Great Britain. The present report is based on the catch of aphids in a yellow pan water trap placed 15 cm above ground on a cultivated terrace at Kalimpong (alt. c. 1209 m a s l) during 1970–1971.

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MATERIAL AND METHODS

A yellow pan water trap of 50 cm×35 cm slanting inwards to a depth of 7.5 cm thus making the bottom measurements of 46 cm×31 cm was operated for collection of alate aphids. It was operated from January to May and November to December during 1970 and in 1971 excepting January, 1970. The trap was replaced with a similar one when it lost the brilliance of chrome yellow colour. Every day, on the days of operation of the trap, collection of the aphids from the trap was done at 2 hourly interval from 6 AM to 6 PM and separate records of number of aphids collection were maintained.

The meteorological data for period of study was obtained from the Kalimpong Station of Indian Meteorological Department, Government of India and the data is presented in Table 1.

RESULTS AND DISCUSSION

The pattern of trapping of the alates of aphids in different months indicated some interesting trends. It was found that during cooler months i.e., from November to first fortnight of February the trapping of alates gradually increased from morning and the maximum number was trapped between 10 AM and 12.00 noon. Then gradually the rate of trapping decreased as the day

TABLE 1. Some meteorological data of Kalimpong.

Month	Fort-night	Av. temp. °C		Av. R H %		Total rainfall in mm	No. of rainy days
		Max.	Min.	8–30AM	5–30PM		
1970							
February	1	12.4	3.9	61.4	63.0	..	..
	2	16.4	6.9	59.9	59.9	14.0	2
March	1	18.9	8.7	66.5	65.8	15.0	2
	2	23.6	13.5	69.3	73.0	1.4	1
April	1	24.6	13.8	68.1	69.0	4.6	1
	2	23.6	13.5	74.3	73.3	24.8	4
May	1	26.1	15.5	70.8	72.5	76.19	6
	2	26.4	16.6	74.7	79.5	30.10	3
November	1	24.0	13.5	67.7	67.3	..	..
	2	18.8	9.5	66.1	68.0	..	..
December	1	18.1	8.3	64.9	66.1	..	..
	2	18.2	9.9	80.8	73.8	..	..
1971							
January	1	16.6	8.8	70.3	53.8	..	..
	2	15.7	8.5	76.6	71.3	4.0	..
February	1	15.6	8.9	78.6	81.7	..	..
	2	15.7	8.4	81.8	80.3	4.0	..
March	1	16.5	8.2	70.8	69.1	..	..
	2	18.8	10.1	56.8	56.3	9.1	3
April	1	19.2	9.5	56.9	56.3	106.27	11
	2	18.1	8.3	55.6	54.1	67.29	8
May	1	17.9	7.9	54.4	54.2	65.42	12
November	1	20.0	10.4	58.3	59.5	6.5	2
	2	19.3	8.0	53.6	56.0	3.5	2
December	1	19.3	6.7	44.9	49.2	..	..
	2	19.0	5.9	44.1	47.2	..	..

approached dusk. During these months there was no trapping before 6 AM and after 4 PM as was indicated by the absence of alates during the time of observation at 6 AM and 6 PM. Therefore, during this period of year the alates became air borne after 6 AM in the morning and remained afloat upto 4 PM and settling of alates also was restricted between 6 AM and 4 PM.

The records of trapping of alates during the warmer periods of the present study indicated a different trend. The data of trapping between second fortnight of February and May revealed that the greater trapping of alates occurred during the time between 8 AM and 10 AM and again between 2 PM and 4 PM. From these it may be assumed that the alates became air borne or

settle to substrate in greater numbers twice a day during this period of the year. From the records of trapping it was further observed that during warmer month the duration of trapping in the day lengthened. The find of alates at 6 AM and again at 6 PM was testimony to this fact. As the day length became longer additional observations were also taken in regard to the presence of alate in the trap at 5 AM and 7 PM i.e. at dawn and at dusk but no alate could be found in the trap during these observations. This indicated that the alates became air borne between 5 AM and 6 AM in the morning and settling of the alates was completed by 6 PM and that during warmer months also no settling of the alate occurred during night.

The data on the alates trapped before noon during the months under observation are presented in Table 2. The proportion of the alates trapped before and after 12.00 noon was found to have some seasonal relation as appears from data of 1970. During this year it appeared that more than 65% of the alates were trapped before 12·00 noon during cooler period from November to first fortnight of February but during warmer months i.e., from second fortnight of February to May less than 45% of the alates were trapped before noon excepting second fortnight of March when 51.10% of the alates were trapped before noon. The data of 1971 do not exactly conform with that of 1970. During 1971 more or less 60% of the alates were trapped before 12 noon during the period of November to February excepting second fortnight of January and first fortnight of February when 56.65% and 54.62% respectively were trapped. From March to May this was

TABLE 2. Percentage of alates trapped before 12 noon IST over the total catch of each fortnight.

Month	Fortnight	1970		1971	
		Total for fortnight	% trapped before 12 noon	Total for fortnight	% trapped before 12 noon
January	1	Not observed		439	65.61
	2			346	56.65
February	1	104	66.35	130	54.62
	2	185	44.28	129	60.46
March	1	345	46.33	562	47.51
	2	683	51.10	525	57.24
April	1	955	46.49	158	61.39
	2	650	40.46	20	50.00
May	1	67	40.30	58	22.23
	2	69	24.64	Not observed	
November	1	131	59.54	32	59.37
	2	324	64.20	290	59.31
December	1	346	75.72	713	59.89
	2	538	70.82	882	57.26

found to be less than 50% though during second fortnight of March and first fortnight of April as much as 57.24% and 61.39% were trapped respectively. In spite of these variations it appeared that more alates during cooler months and fewer during warmer month were trapped before 12.00 noon of the day.

It has been found that when there was only one peak of alates trapped the percentage of the alates trapped formed almost always over 30% of the day's trapping. But during the periods when there were two peaks of alates trapped during the day, the percentage was somewhat lower i.e., almost always less than 25% in each of these two peaks. Here also the exceptions of catch of about 30% of the total catch of the day could be recorded during second fortnight of March of both the years when peak before 12.00 noon was higher than that in the afternoon. However, the total of these two peaks of trapping of alates was always more than 45% of the day's catch (Table 3).

Yellow pan water trap recorded sample of alate aphids from uncontrolled volume of air (TAYLOR & PALMER, 1973) and species that were responsive to the yellow colour were caught in this trap (HEATHCOTE *et al.*, 1969; TAYLOR & PALMER, 1973). Therefore, yellow pan water trap gave results by utilising the settling stimuli of the aphids that were positively attracted to the yellow colour. Taking cognizance of these facts some indirect properties of the air borne aphids can be inferred. The record of yellow pan trap yields some idea of aerial density of alate aphid though it cannot be numerically

TABLE 3. Percentage of alates trapped during peak period of trapping of the day (on total of fortnight's trapping)

Month	Fortnight	Percentage of alates trapped			
		1970		1971	
		At fore-noon peak	At after-noon peak	At fore-noon peak	At after-noon peak
January	1	Not observed		48.29	..
	2	,,		44.21	..
February	1	36.53	..	33.08	..
	2	..	24.46	31.08	..
March	1	22.04	25.14	25.62	20.99
	2	28.40	21.23	33.56	14.46
April	1	21.88	25.76	33.54	..
	2	19.55	26.77	..	35.00
May	1	..	35.82	..	60.34
	2	..	46.37	Not observed	
November	1	30.53	..	31.25	..
	2	41.67	..	40.34	..
December	1	44.79	..	41.51	..
	2	61.52	..	44.04	..

expressed and also the periods of take off of alates from the host plants and their settling on the plants can be found out. Through the present investigation, therefore, it emerged out that (i) the density of alate aphid in air particularly near the ground level attained peak during March–April and December; (ii) the diurnal activity of settling of the aphids attained peak between 10 AM and 12 noon during November to February and between 2 and 4 PM during April–May, indicating one peak of settling activity of alate aphids which occurred in the forenoon in cooler months and in the afternoon in warmer months; (iii) there were usually two peaks of settling of alates during March-April, and (iv) alate aphids did not settle during night in yellow pan trap. EASTOP's (1951) data revealed that there occurred two peaks of aerial density of aphids when all the species were taken into consideration and that aphids remained air borne even after dusk. It was not known whether aphids remained air borne during night in this region as sampling of alates were not done in controlled volume air sampler like suction traps as was done by EASTOP (1951). As in the yellow pan water trap the attraction of the aphid to the colour was utilised for study the absence of trapping during night may be explained by the observations of HALGREN & TAYLOR (1968) and DRY & TAYLOR (1970) which indicated that response declined as the light intensity decreased and the temperature below 15°C deferred flight activities of species they studied.

The present study revealed that specific studies on individual species of aphids on the factors influencing alate activities will provide valuable information on the dispersal of this important group of insect, crop infestation probabilities and also indicated the major period of the take off and settling of the alates from and on the crops.

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SOME PARASITES AND PREDATORS OF APHIDS IN NORTHEAST INDIA AND BHUTAN–II

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This paper reports some parasites and predators of aphids from northeast India. Among the parasites 3 are new records for India and among the predators 4 coleopteran and 1 dipteran insects and 4 spiders are likewise newly reported from India. New aphid hosts have been recorded for some of the parasites and predators. Besides, the present survey has extended the knowledge of distribution of a few parasites and predators of aphids.

(*Key words:* **parasites and predators of aphids**)

Raychaudhuri, D. N. et al. (1978) reported some parasites and predators of aphids from northeast India and Bhutan. The present paper is a continuation of the previous one. Here six parasites belonging to the order Hymenoptera, twelve coleopteran, three dipteran insect predators and nine spider predators of aphids are reported. Some of these parasites and predators could not be indentified up to species level. Those parasites or predators which are reported for the first time from India have been denoted with one (*) mark. For new aphid hosts in respect of either parasites or predators two (**) marks and for new localities in the area of survey three (***) marks have been used. A list contianing the parasites and predators of aphids along with necessary data is provided below. Examples of the parasites and the predators are in the collection of Entomology Laboratory, Department of Zoology, University of Calcutta.

APHID PARASITES

1. Aphidius colemani Viereck

Host : ** *Hyalopterus pruni* (Geoff.) from *Prunus cerasus*, 30. iii. 1977, Ghaspani, Nagaland***.

Krishnamurti and Usman (1954) reported this parasite from *Aphis* sp. on tobacco from Bangalore.

2. *Aphidius rosae Haliday**

Host : *Macrosiphum rosae* (L.) from *Rosa* spp. 22. iv. 1976, Kalimpong, West Bengal, 12.v.1976, Gangtok, Sikkim.

3. Aphidius sp.

Hosts : **Brachycaudus helichrysi* (Kalt.) from an unidentified host plant, 1.iii.1977, Zunheboto, Nagaland ***; **Hyalopterus pruni* (Geoff.) from *Prunus cerasus*, 14. ii. 1977, Ghaspani, Nagaland; **Lachnus tropicalis* (v.d. Goot) from an unidentified host plant, 14.ii.1977; Ghaspani, Nagaland.

Rao (1969) reported the incidence of the genus *Aphidius* on a number of aphid hosts excepting the aforesaid ones in different parts of India.

4. Ephedrus plagiator (Nees)

Hosts : ***Ceratovacuna silvestrii* (Takahashi) from *Saccharum officinarum*, 19.xii.1976, Kalimpong, West Bengal; *Myzus persicae* (Sulzer) from *Brassica oleracea*, 4.v.1976, Gangtok, Sikkim***.

Rao (1969) and Raychaudhuri et al. (1978) have reported the occurrence of this parasite from many aphid hosts in south India and north east India respectively. Present aphid is an addition to the lists of aphid hosts for this parasite.

5. *Indaphidius carvicaudatus Stary (Ms. name)

Hosts : *Macrosiphum rosae* (L.) from *Rosa* sp. 13. xii. 1976; *Mollitrichosiphon* (*Metatrichosiphon*) *nandii* Basu from *Alnus nepalensis*, 10.xii.1976, Kalimpong, West Bengal, 20. xii. 1976, Gangtok, Sikkim.

This species is being described separately.

6. *Trioxys (Betuloxys) takecallis Stary (Ms. name)

Host : *Takecallis arundinariae* from a plant of Gramineae, 19. xii. 1976 Kalimpong, West Bengal.

This species is being described separately.

APHID PREDATORS

A. Insects

Order : Coleoptera

Family : Chrysomelidae

1. *Gallerucida bicolor (Hope)

Host : *Macrosiphum rosae* (L.) from *Rosa* sp., 12.v.1976, Kalimpong, West Bengal. Predatory stage : Adult.

2. *Monolepta signata (Oliv.)

Host : *Macrosiphum rosae* (L.) from *Rosa* sp., 12.v.1976, Kalimpong, West Bengal. Predatory stage : Adult.

Family Coccinellidae

3. Ballia sp.

Host : *Myzus persicae* (Sulzer) from *Gynura angutosa*. 6.v.1976, Ranipul, Sikkim***.

4. Coccinella septumpunctata L.

Hosts : *Aphis gossypii* Glover group from *Bidens pilosa*, Namchi; from *Duranta plumeri*, 16.v.1976, Sintam, Sikkim***; *Brachycaudus helichrysi* (Kalt.) from *Artemisia* sp., 7.v. 1976, Mangan, Sikkim; ** *Macrosiphum rosae* (L.) from *Rosa* spp. 7.v.1976, Mangan, Sikkim; 12.v.1976, Kalimpong, West Bengal; ***Toxoptera aurantii* (B.d.F.) from *Citrus* sp. 7.v.1976, Mangan, Sikkim.

Predatory stage : Both grub and adult.

5. Coelophora sexareata Mulsant

Hosts : ***Macrosiphum rosae* (L.) and ***M.* (*Sitobion*) *roseiformis* Das from *Rosa cania*, 13. v. 1976, Kalimpong, West Bengal. Predatory stage : Adult.

6. Coelophora sp.

Host : ***M. rosae* (L.) from *Rosa* sp., 13.v.1979, Kalimpong, West Bengal.

7. *Chilocorus rubidus Hope

Hosts : *M. rosae* (L.) and *M.* (*S.*) *rosaeiformis* Das from *Rosa* sp. 13.v.1976, Kalimpong, West Bengal.

Predatory stage : Adult.

8. Cryptogonus quadriguttatus (Weise)

Hosts: ***M. rosae* (L.) and *M.* (*S.*) *rosaeiformis* Das from *Rosa* sp., 13. v. 1976, Kalimpong, West Bengal.

Predatory stage : Both grub and adult.

Raychaudhuri et al. (1978) reported this coccinellid as predatory on *Melanaphis sacchari* from eastern India.

9. Nephus sp.

Host : ***Astegopteryx minuta* (v.d.Goot) from *Bambusa* sp., 24. ii. 1977. Dimapur, Nagaland***.

Predatory stage : Adult.

10. Oenopia kirbyi Mulsant

Hosts : ***M. rosae* (L.) and *M.* (*S.*) *rosaeiformis* Das from *Rosa* sp. 13.v.1979, Kalimpong, West Bengal.

Predatory stage : Adult.

Rao (1969) recorded this predator from *Aphis solanella* in Kalimpong.

11. Oenopia luteopustulata Mulsant and **O.** nr. **luteopustulata** Muls.

Hosts : ***M.rosae* (L.) and M. (*S.*) *rosaeiformis* Das from *Rosa* spp. 13.v.1976, Kalimpong, West Bengal.

Predatory stage : Both grub and adult.

12. *Oenopia nr. quadripuncta Kapur

Host : *Aphis fabae solanella* Theobald from *Quercus* sp., 7.v.1976 Mangan, Sikkim,

Predatory stage : Adult.

Order : Diptera

Family : Syrphidae

13. *Sphaerophoria scripta L.

Hosts : *M. rosae* (L.) and *M.* (*S.*) *rosaeiformis* Das from *Rosa* spp. 19.xii. 1976, Kalimpong, West Bengal.

14. Syrphus balteatus De Geer

Hosts : *Myzus persicae* (Sulzer) from *Solanum · tuberosum,* 6.v.1976, Gangtok, Sikkim***.

15. Syrphus serarius Wied

Host : ***Cryptomyzus taoi* Hille Ris Lambers from an unidenified plant, 24. ii. 1977, Dimapur, Nagaland***.

In all cases of dipteran predators only larvae were found to feed on aphids.

B. Spiders

Order : Araneida

Family : Araneidae (=Argiopidae)

16. *Cyclosa insulana (Costa)

Host : *Aphis craccivora* Koch from *Vicia faba,* 12.xii. 1977, Kalimpong, West Bengal.

17. *Leucauge celebesiana (Walckenaer)

Hosts : *Aphis craccivora* Koch from *Vicia faba,* 12. xii. 1977, Kalimpong; *Aphis gossypii* Glover group from *Galinsuga parviflora,* 14. xii. 1977, Kalimpong, West Bengal.

18. *Neoscona nautica (Koch)

Host : *Macrosiphum rosae* (L.) from *Rosa* sp. 4. iii. 1978, Kalimpong, West Bengal.

Two other species of spiders have been reported as predators of this aphid species (Raychaudhuri et al. 1978).

19. *Neoscona sp.

Host : *Nippolachnus piri* Matsumura from *Pyrus communis,* 8.xi. 1977, Kunglong, Bhutan.

This is the first report of a spider predating on any aphid species so far known from Bhutan.

Family : Linyphiidae

20. Linyphia sp.

Host : ***Taoia indica* (Ghosh and Raychaudhuri) from *Alnus nepalensis,* 10.iii. 1978, Kalimpong, West Bengal***.

Raychaudhuri et al. (1978) reported this spider from Manipur feeding on *Hyalopterus pruni.*

Family : Salticidae)

21. ***Marpissa** sp.

Host : *Cinara tujafilina* (Del Guercio) from *Cupressus* sp., 10. iii. 1978, Kalimpong, West Bengal.

Bradley and Hinks (1968) have recorded 6 species of spider predators belonging to family Salticidae feeding on some species belonging to the aphid genus *Cinara* but not on *tujafilina* from Canada. Raychaudhuri et al. (1978) however, recorded *Theridion* sp. to feed on *tujafilina* in the same locality.

Family : Theridiidae

22. Theriodion sp.

Host : ***Aphis craccivora* Koch on an unidentified plant, 14. iii. 1978 Kalimpong, West Bengal.

Family : Thomisidae

23. ***Thomisus** sp.

Host : *Macrosiphum rosae* (L.) from *Rosa* sp. 14. iii. 1978 Kalimpong, West Bengal.

Family : Uloboridae

24. ***Uloborus** sp.

Host : *Aphis gossypii* Glover group from *Tagetes patula,* 4.iii.1978, Kalimpong, *Cinara tujafilina* (Del Guercio) from *Cupressus* sp. 10. iii. 1978, Kalimpong, West Bengal.

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TWO NEW SPECIES OF *DROSOPHILA* (DIPTERA : DROSOPHILIDAE) FROM SHILLONG, MEGHALAYA

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An account is given of seven species representing the subgenus *Drosophila*; out of them *Drosophila penispina* and *Drosophila novaspinofera* are described as new, while *Drosophila annulipes* and *Drosophila fuscicostata* are recorded for the first time from India.

(*Key words:* new *Drosophila*)

Recent collections of *Drosophila* from different areas in northeast India have made significant addition of several interesting species to the list of Indian fauna (Gupta and Singh, in press; Singh and Gupta, in press). In the present paper authors report the results of their further studies undertaken at and around Shillong, with particular concern to the species representing the subgenus *Drosophila* in this region.

Genus *Drosophila* Fallén

Drosophila Fallén, 1823, Diptera Sueciae Geomyz., 2:4. Type species: *Musca funebris* Fabricious; Sweden.

Subgenus *Drosophila* Fallén.

Drosophila Fallén, 1823, Diptera Sueciae Geomyz., 2:4; Sturtevant, 1939, Proc. Nat. Acad. Sci., 25:139; Sturtevant, 1942, Univ. Texas Publ., 4213:30.

Bands on abdominal tergites, when present, usually interrupted medially, at least on basal segments; cheek often broad; egg usually with 4 filaments; ventral receptacle generally long and finely coiled.

1. Drosophila (Drosophila) penispina sp. nov. (Figs. 1A–D)

Male and Female: Arista with about 4–5 dorsal and 2–3 ventral branches in addition to the small terminal fork. Antennae with second segment pale tan; third segment pale. Frons including ocellar triangle pale tan, subshining, carina broad, high. Face and cheek tan, greatest width of cheek from base of oral to eye border about one sixth the greatest diameter of eye. Orbitals in the ratio of 9:4:11. Second oral subequal to vibrissa. Palpi pale, with 3–4 marginal setae. Eyes bright red.

Acrostichal hairs regular, in 8 rows between dorsocentrals. Anterior scutellars convergent. Distance from anterior dorsocentral to posterior dorsocentral about two fifths the distance between 2 anterior dorsocentrals. Mesonotum and scutellum unicolorous, dull yellow, becoming little brownish with age. Thoracic pleura dull yellow. Sterno-index about 0.7. Legs yellowish, last tarsal segments dark brown, preapicals on all three tibiae; apicals on first and second tibiae.

Wings (Fig. 1D): Transparent, posterior cross vein clouded. Approximate indices:

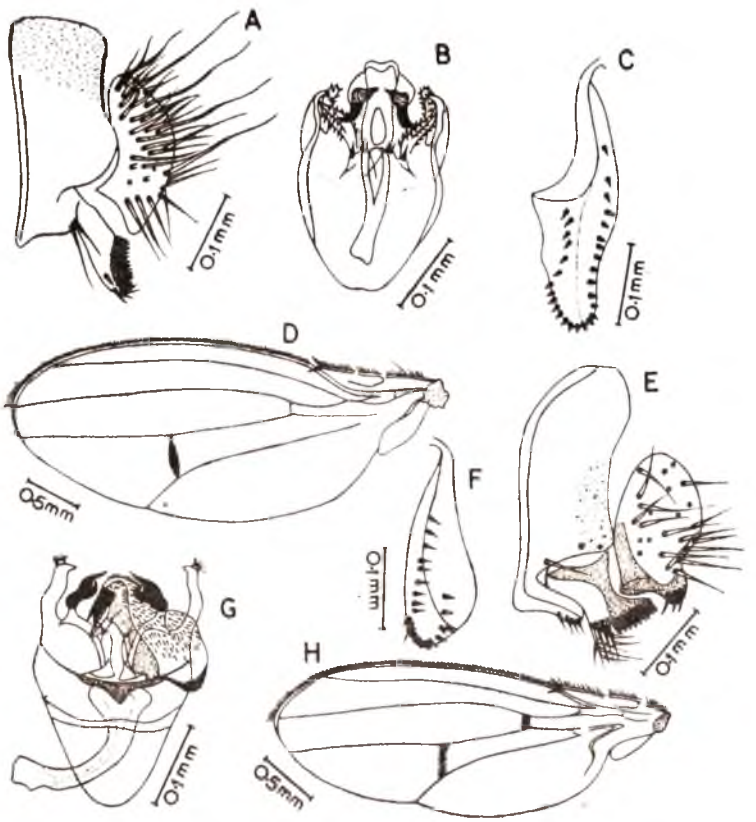

Fig. 1. (A–D): *Drosophila penispina* sp. nov. A, periphallic organs; B, phallic organs; C, egg guide; D, male wing. (E–H): *Drosophila novaspinofera* sp. nov. E, periphallic organs; F, egg guide; G, phallic organs; H, male wing.

C-index 5·9; 4 V-index 1·27; 4 C-index 0.39; 5 X-index 0.95. Two equal bristles at the apex of first costal section; heavy bristles on about basal one third of third costal section. Halteres dull yellow.

Abdomen yellowish, with medianly interrupted faint brownish apical bands which fade away entirely laterally, in male last tergite all black.

Periphallic organs (Fig. 1 A) : Genital arch broad dorsally and narrowing ventrally, upper portion bare and little pubescent, lower portion with about two large bristles. Primary clasper with about 10–11 stout black teeth arranged on outer concave row, one tooth placed a little apart from the remaining teeth, and about 5–6 short stout setae at lower tip. Anal plate black, semi-lunar, with about 5 large thick and several thin small bristles.

Phallic organs (Fig. 1 B) : Aedeagus short and straight, subapically on either side with thick black curved spines; basal apodeme of aedeagus thick and short. Anterior parameres fused with novasternum, and with about 2 apical sensilla. Posterior parameres large, curved apically, with several conical processes. Novasternum with a pair of small submedian spines. Ventral fragma somewhat triangular.

Egg guides (Fig. 1C) : Lobes broadly rounded at tip, with about 23 marginal and 6 discal teeth. Basal isthmus narrow and short.

Average lenth of male body (from 10 males) : 3.38 mm.

Average length of female body (from 10 females) : 3.61 mm.

Holotype ♂, INDIA: MEGHALAYA: Motinagar forest, Khasiya hill, Shillong district, 30. iv. 1976, J. P. Gupta and B. K. Singh. Deposited in the Museum of Department of Zoology, Banaras Hindu University, Varanasi, India. **Paratypes** : 15 ♂♂, 20 ♀♀ same locality and collectors as holotype. Deposited in Meseum of Department of Zoology, B. H. U., Varanasi and Department of Biology, Tokyo Metropolitan University, Tokyo, Japan.

Distribution : India.

2. Drosophila (Drosophila) novaspinofera sp. nov. (Figs. 1E–H)

Male and female : Arista with about 5 dorsal and 2 ventral branches in addition to the terminal fork. Antennae with second segment tan; third segment darker. Frons pale, with ocellar triangle brown. Carina tan, high and broad below. Face and cheek pale, greatest width of cheek from base of oral to eye border about one fifth the greatest diameter of eye. Orbitals in the ratio of 8:4:10. Palpi yellow, with about 3 prominent marginal setae. Second oral subequal to vibrissa. Eyes bright red.

Acrostichal hairs regular, in 8 rows between dorsocentrals. Anterior scutellars slightly convergent. Distance from anterior dorsocentral to posterior dorsocentral about one third the distance between 2 anterior dorsocentrals. Mesonotum and scutellum unicolorous yellow. Thoracic pleura dark yellow. Sterno-index about 0.76. Legs yellow, preapicals on all three tibiae; apicals on first and second tibiae.

Wings (Fig. 1H): transparent, crossveins slightly fuscous. Approximate indices: C–index 4.00; 4V–index 1.7; 4C–index 0.67; 5X–index 1.3. Two small equal bristles at the apex of first costal section; heavy on about basal half of third costal section. Halteres yellow.

Abdomen yellow, anterior 2–3 tergites with dark and narrow apical bands, posterior tergites with very faint bands.

Periphallic organs (Fig. 1E): Genital arch broad; heel high and rectangular; toe narrow and forming an obtuse angle; upper portion almost bare, lower portion with about 7-8 bristles. Primary clasper large, nearly quadrate, with about 10 black stout teeth arranged in a straight row and with about 4 large bristles as well as a tuft of 8–9 short bristles at lower tip of clasper. Anal plate oval, with about 25 long bristles above, lower tip slightly narrowed and with about 3 black, short curved bristle like teeth.

Phallic organs (Fig. 1G): Aedeagus short and compact, basally swollen, covered with fine setae, apical portion directed ventrad, with serrated inner lobe and with two outer black teeth; basal apodeme longer than aedeagus. Anterior parameres small, each with an apical sensillum. Posterior parameres obscure. Novasternum with developed lateral processes and with 2 pairs of black hooked scaly submedian spines. Ventral fragma broader than long.

Egg guides (Fig. 1F): Lobe rounded at tip, with about 17 marginal and 3–4 discal teeth. Basal isthmus narrow and short.

Length of male body (from 1 male) : 3.08 mm.

Length of female body (from 1 female) 3.51 mm.

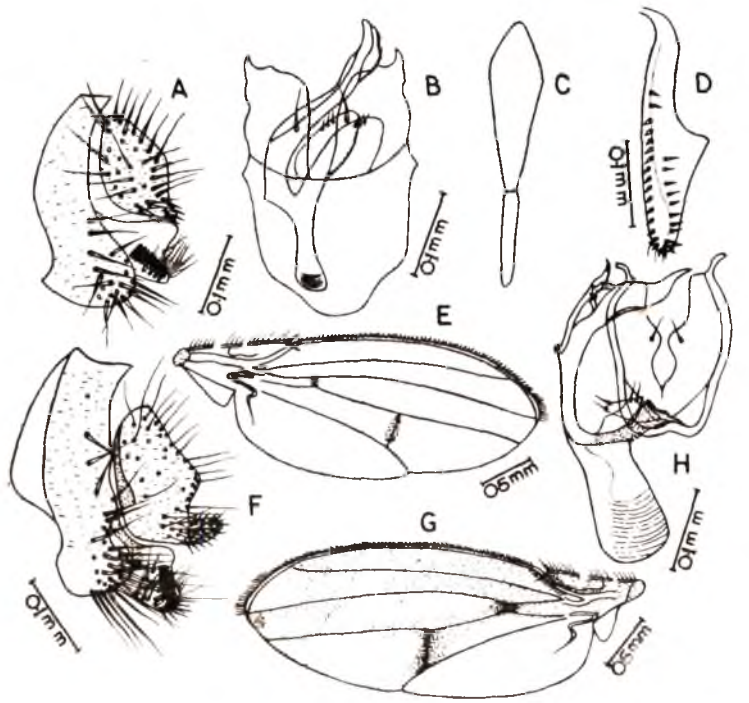

Fig. 2. (A–E): *Drosophila annulipes* A, periphallic organs; B, phallic organs; C, aedeagus (dorso-ventral view); D, egg-guide; E, male wing. (F–H): *Drosophila fuscicostata* F, periphallic organs; G, male wing; H, phallic organs.

Holotype ♂, genitalia on slides; INDIA: MEGHALAYA: Motinagar forest, Khasiya hill, Shillong district, 30. iv. 1976, J. P. Gupta and B. K. Singh. Deposited in the Museum of Department of Zoology, Banaras Hindu University, Varanasi, India. **Paratype**: 1 ♀, same locality and collectors as holotype. Slides deposited in the Museum of Department of Zoology, B.H.U., Varanasi, India.

Remarks : *Drosophila novaspinofera* probably belongs to *quinaria* section

Distribution : India.

3. **Drosophila (Drosophila) annulipes** Duda (Figs. 2A–E)

Drosophila annulipes Duda, 1924, Archiv Naturgesh. A, 90 (3) : 209, 221, 250; Duda, 1923, Mus. Nat. Hungarici, ann. 20 : 58 (nomen nudum)

Male and female: General features as described by Tan, Hsu and Sheng (1949), Okada (1956), and Wheeler and Takada (1964).

Wings (Fig. 2E): Transparent, cross veins clouded. Approximate indices: C–index 4.5: 4V–index 1.37; 4C–index 0.52; 5X–index 1.0.

Periphallic organs (Fig. 2A): As described by Okada (1956).

Phallic organs (Fig. 2B): As described by Okada (1955).

Egg guides (Fig. 2D): Lobe somewhat elongated, and with about 22 marginal and 8 discal teeth.

Distribution ; Formosa, China, Korea, Japan, Bonin Island, Nepal and India (New record).

4. Drosophila (Drosophila) fuscicostata Okada (Figs. 2F–H)

Drosophila fuscicosta Okada, 1966, Bull. Br. Mus. (Nat. Hist.) Ent. Suppl. 6;111.

Male: General features as described by Okada (1966).

Wings (Fig. 2G): Largely fuscous extending from costal margin to R_{2+3} below, apically of R_{4+5} cells as well as in the vicinity of cross veins. Approximate indices: C–index 4.0; 4V–index 1.8; 4C–index 0.7; 5X–index 1.1.

Periphallic organs (Fig. 2F) and phallic organs (Fig. 2H) as described by Okada (1966).

Distribution : Nepal and India (New record).

5. Drosophila (Drosophila) albomicans Duda

Duda 1923:43, 47, 48; 1924a:209; 1924b: 245, Fig. 70; 1926: 83, 88–89; 1940: 23. *D. komaii* is a probable synonym.

Male and female: General features as described by Duda (1524).

Specimen examined: 50♂♂, 35♀♀, April 1976, Shillong, Meghalaya.

Distribution: Okinawa, Taiwan (Formosa), Pescadores Islands, Thailand and India.

6. Drosophila (Drosophila) nasuta Lamb

Drosophila nasuta Lamb, 1914, Trans. Linn. Soc. 16: 346.

Male and female : General features as described by Lamb (1914) Harrison (1954) and Wheeler and Takada (1964).

Specimen examined: 32♂♂, 21♀♀, INDIA; MEGHALAYA: Shillong, iv. 1976

Distribution : Borneo, Sumatra, Formosa, Moluccas, New Guinea, Samoa, Fiji, Hawaii, Micronesia, Seychelles, India.

7. Drosophila (Drosophila) immigrans Sturtevant

Drosophila immigrans Sturtevant, 1921, Carnegie Inst. Washington Publ. 301 : 83.

Male and female : General features as described by Sturtevant (1921), Patterson (1943) and Kikkawa and Peng (1938).

Specimen examined : 202♂♂, 110♀♀, INDIA, MEGHALAYA, Shillong, iv. 1976

Distribution ; Cosmopolitan.

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FOUR NEW SPECIES OF *IDIOSCOPUS* (HOMOPTERA : CICADELLIDAE) FROM SOUTHERN INDIA

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Four new species of *Idioscopus* Baker, namely, *robustipennis* sp. nov., *webbi* sp. nov., *indicus* sp. nov., and *lalithae* sp. nov. from the states of Karnataka and Kerala are described and illustrated. A key to the Indian species of *Idioscopus* is also provided.

(*Key words:* **new *Idioscopus* from India**)

So far 18 species of *Idioscopus* Baker, including *Idioscopus nigroclypeatus* (Melichar) which has been relegated to the status of a species distinct from *I. clypealis* (Lethierry) (Rao, 1976), have been described from the Indian subcontinent (Viraktamath, 1976 and 1978). Four new species of *Idioscopus* discovered recently from the states of Karnataka and Kerala are described here.

The holotypes of the species described here will be deposited in the Zoological Survey of India, Calcutta, and the paratypes in the British Museum (Natural History), London, U. S. National Museum, Washinton, D. C. and in the University of Agricultural Sciences, Bangalore.

1. Idioscopus robustipennis sp. nov. Figs. 1–5

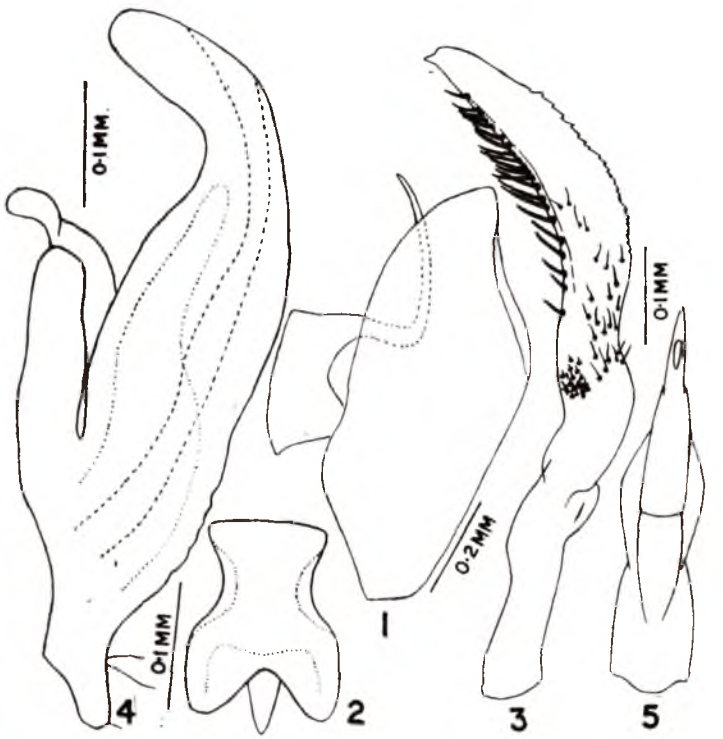
Ochraceous. Eyes black. Two triangular spots at base of scutellum black. Forewings pale brown. Apices of hindtibiae reddish brown, claws fuscous.

Vertex slightly longer medially than next to eye, 3 times as wide between eyes as its median length, transversely rugose. Face wider than long, dorsad of ocelli rugose. Pronotum 1.84 times as long as median length of vertex, 2.5 times as broad as its length, shagreened. Scutellum longer than pronotum, shagreened. Veins of forewing with double row of punctures and with four apical and two anteapical cells. Dorso-lateral row of hindtibiae with three stout teeth subapically below each arises a apine in *Balcanocerus balcanicus* (Horvåth) and *Idiocerus exus* Freytag and Knight.

Male genitalia : Pygofer with well developed cephalic apodemes; its caudo-ventral margin sinuate with membranous margin. Anal collar process slender, elongate projected beyond pygofer dorsally and slightly diverging laterally making almost a right angle to the anal collar at base. Connective T-shaped with an anterior median process. Apophysis of style flattened with serrated ventral margin, laterally curved with apical tooth, dorsal margin lined with setae. Aedeagus short robust, with lateral furrow, caudally broad in the middle, apically laterally compressed and recurved anteriorly; gonopore subapical, elongate and on caudal margin.

Unique male measured 4.5 mm in length and 1.55 mm in width.

Holotype ♂, INDIA : KARNATAKA, 36 KM. W. Jog Falls, 18.xi.1976, C.A. Viraktamath.



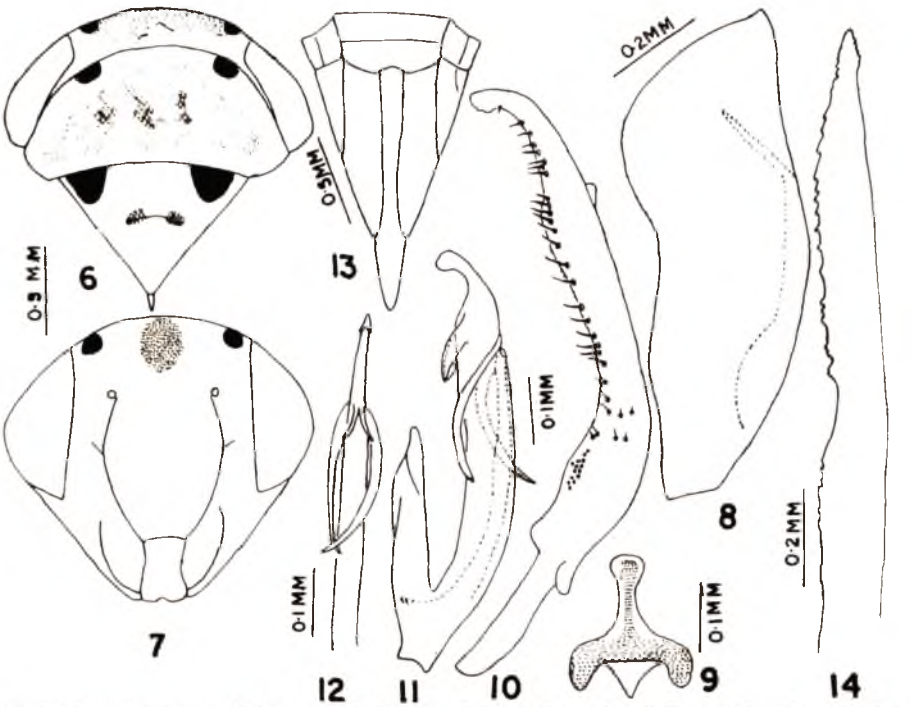
Figs. 1–5 *Idioscopus robustipennis* sp. nov. 1. Male pygofer; 2. Connective, dorsal view; 3. Male style, lateral view; 4. Aedeagus, lateral view; 5. Aedeagus caudal view.

Remarks : *I. robustipennis* is unique among the species of *Idioscopus* in having laterally furrowed and short aedeagal shaft.

2. Idioscopus webbi sp. nov. Figs. 6–14

Vertex ochraceous laterally, medially with a large brown spot extending on face apically; two round spots on anterior margin black, in a few specimens (3 out of 6) a central large blackish spot on anteriormost margin extending on dorsal aspect of face. Face ochraceous to yellow, in all females and in males lacking the central large spot on face, most of the clypellus black. Antennal disc of male black. Eyes black. Disc of pronotum brownish, with anterior, lateral and posterior margins ochraceous; two round spots on anterior margin partly covered by vertex black. Scutellum brownish yellow, two somewhat triangular spots partly covered by pronotum black; two spots on oblique impressed line dark brown. Forewings smoky, 2/3 of costa and claval margin yellow, venation dark brown. Legs ochraceous, bases of hindtibial spines and apices reddish brown. Mesothoracic sterna blackish; abdominal sterna, lateral borders of terga yellowish; terga medially black.

Vertex more or less of uniform length, 4 to 5 times as wide between eyes as its median length, transversely rugose. Face wider than long, shagreened; frontal sutures just reaching ventrad of ocelli, lora well separated from genae, clypellus slightly widened apically and excavated at apex in the middle. Labium slender elongate,



Figs. 6–14 *Idioscopus webbi* sp. nov. 6. Head and thorx of female; 7. Face of female; 8. Male pygofer; 9. Connective, dorsal view; 10. Male style, lateral view; 11. Aedeagus, lateral view; 12 Aedeagus, caudal view; 13. Female genitalia; 14. Second valvula.

extending slightly beyond metacoxae. Few males (possessing central black spot) with antennal disc, other males lacking such disc. Pronotum 2.6 to 3 times longer than median length of vertex and 2.2 to 2.4 times as wide as its median length, shagreened. Scutellum longer than pronotum, posterior to the median impressed line irregularly rugose. Second abdominal tergum with strongly developed tergital apodemes extending well beyond third abdominal tergum.

Male genitalia : Pygofer elongate with a short ventral process, dorsally heavily pigmented and with an unsclerotised area in the middle, its dorso anterior border with well developed apodeme. Anal collar well developed with a finger like caudally directed process. Male plates long and narrow covered with hair like setae, but shorter than pygofer. Connective elongate T-shaped with a short median process on anterior margin. Style with a laterally curved apex and with a subapical lobe like process, its lateral margin with a row of microscopic setae. Aedeagus with a well developed dorsal apodeme forming a 'V' with the shaft; shaft laterally compressed with a pair of long, curved ventrally somewhat asymmetrically directed processes arising just dorsad of gonopore on caudal margin and with a pair of short processes at the same position but arising on the enterior margin which diverge laterally; apex of shaft recurved anteriorly; gonopore subapical.

Female genitalia : Hindmargin of seventh sternite with a shallow concave median excavation. Ovipositor extending well

beyond pygofer. Second pair of valvulae irregularly serrated beyond egg pore and also just before it (Fig. 14).

Measurements : Male 4.7 (4.64–4.79) mm in length and 1.7 (1.65–1.75) mm in width; female 4.78 (4.7–4.93) mm in length and 1.8 (1.78–1.85) mm in width.

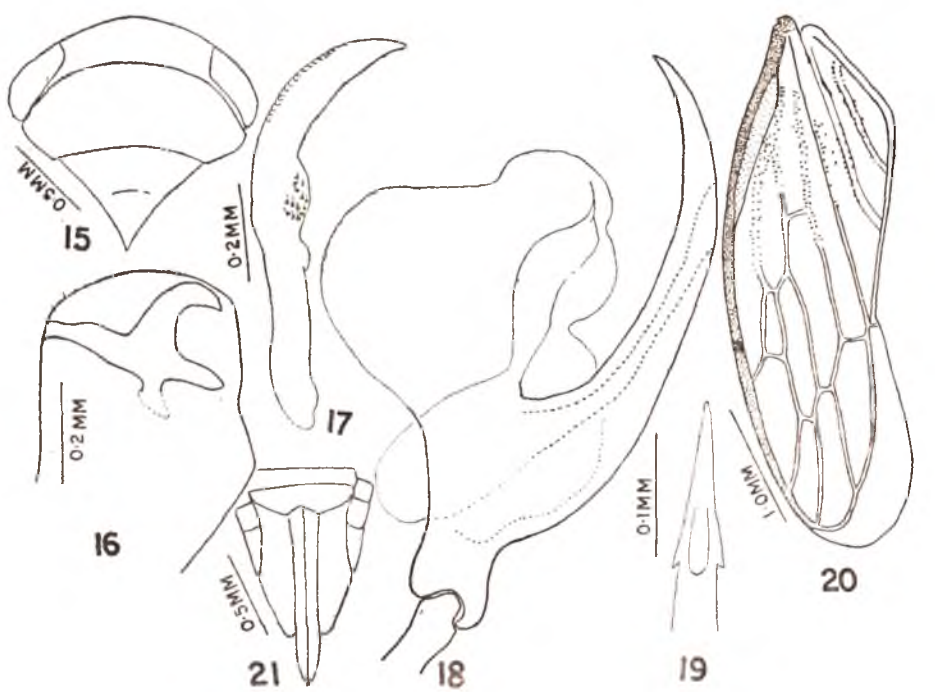
Holotype ♂ INDIA : KERALA, Maraiyur, 24. ii. 1977, C. A. Viraktamath, **paratypes** 5♂♂ and 3 ♀♀ with same locality data but collected by C. A. Viraktamath (2 ♂♂ and 1 ♀), Shashidhar Viraktamath (1 ♂ and 1 ♀) and by B. Mallik (2♂♂ and 1 ♀).

Remarks : Externally this species resembles *Amritodus brevistylus* Viraktamath, but the structure of aedeagus clearly distinguishes this. It shares the character of ventral pygoferal process with *I. virescens* Viraktamath but can be easily distinguished by its colour, size and by the structure of male genitalia. The species is named in honour of Mr. M. D. Webb, British Museum (Natural History), London.

3. **Idioscopus indicus** sp. nov. Figs. 15–21

Uniformly green in life. Preserved specimens greenish ochraceous. Scutellum in two specimens with two brown basal triangles. Forewings pale, brown, apices smoky brown, basal half of costa greenish yellow. Tip of ovipositor black.

Head wider than pronotum. Vertex longer medially than next to eye, area dorsad of ocelli transversely rugose, 3.5 to 3.9 times wider than its median length. Face wider than long. Clypellus not extending beyond normal curve of gena. Labium short and stout reaching the apices of mesothoracic coxae. Pronotum shagreened, 2.0



Figs. 15–21 *Idioscopus indicus* sp. nov. 15. Head and thorax; 16. Male pygofer; 17. Male style, lateral view; 18. Aedeagus, lateral view; 19. Tip of aedeagus, caudal view; 20. Forewing of female; 21. Female genetilia.

to 2·3 times longer than median length of vertex and 2.5 times wider than long. Scutellum longer than pronotum, basal half shagreened, apical half transversely rugose. Forewing venation as in Fig. 20, basal half of veins coarsely punctate.

Male genilalia : Pygofer dorsocaudally rounded, anterior margin of ninth tergum with well developed apodeme. Anal collar process apically C-shaped. Style broad, ventrally serrate, caudally curved dorsad and pointed. Aedeagus simple, with two denticles on either side of gonopore. dorsal apodeme well developed. Gonopore subapical and caudal.

Female genitalia : The seventh sternite caudally slightly produced and medially excavated (Fig. 21). Ovipositor extending beyond pygofer.

Measurements : Male 4.36 to 4.46 mm in length and 1.5 mm in width; female 4.5 mm in length and 1.55 mm in width.

Holotype ♂ INDIA : KARNATAKA, Mudigere, 23. v. 1976 C. A. Viraktamath, **paratypes** 2 ♂♂ and 3 ♀♀ with same locality data as holotype but 1 ♂ and 1 ♀ collected on 22. v. 1976 and 1 ♀ collected on 22. v. 1976 by B. Mallik. 1 ♀ paratype India : Karnataka, Jog Falls, 17. xi. 1976, B. Mallik. 2 ♀ ♀ paratypes with same locality data but collected by C. A. Viraktamath one on 17. xi. 1976 and the other on 19. xi. 1976. 1 ♂ paratype India : Kerala, Maraiyur, 24. iii. 1977, Shashidhar Viraktamath. 2 ♀ ♀ paratypes with same data but collected by C. A. Viraktamath.

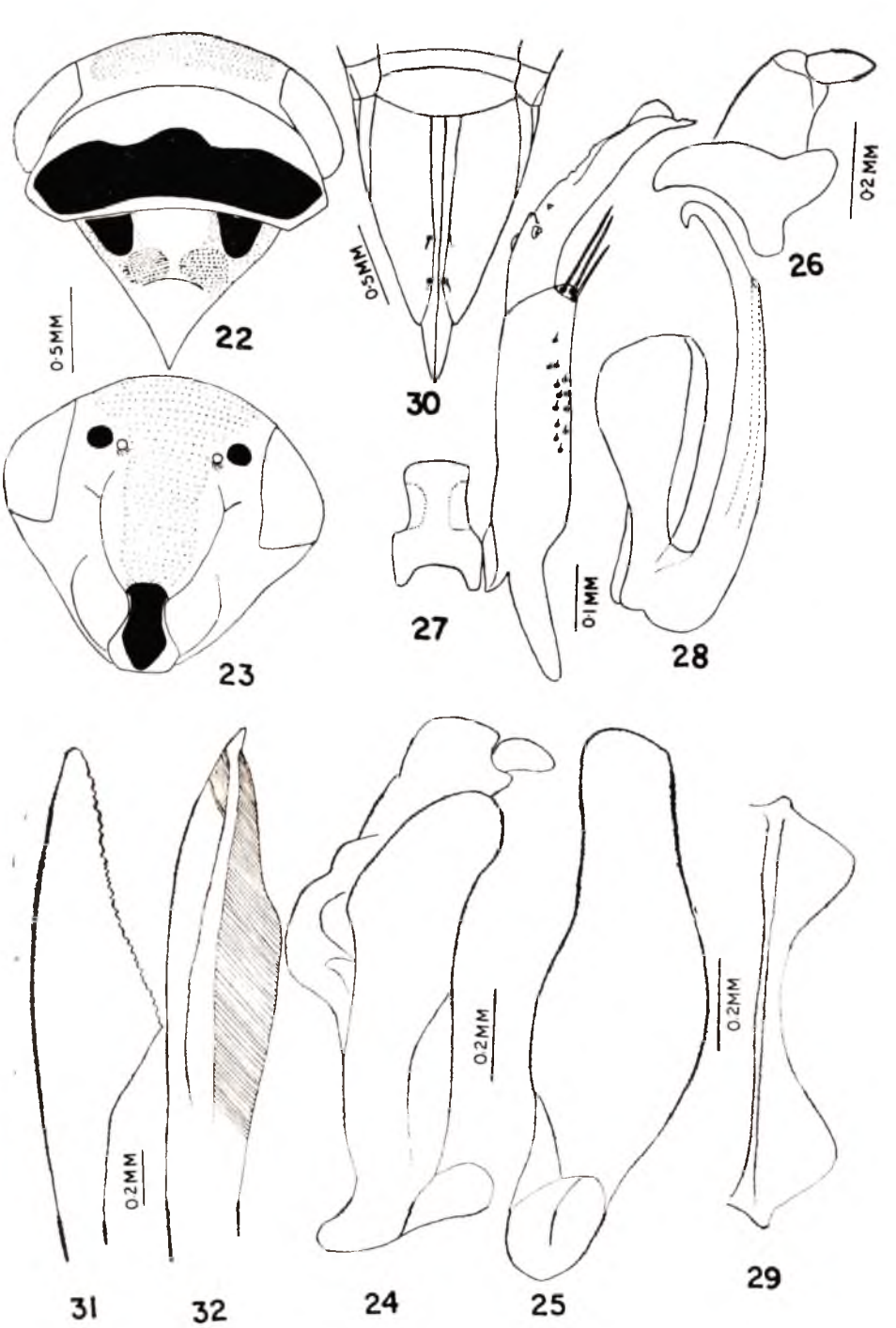
Remarks : This species appears distantly related to *I. decoratus* Viraktamath from which it can be easily distinguished by its coloration and distinct male genitalia. The aedeagus of this species has some resemblance to that of *Balcanocerus balcanicus* (Horváth), but the rugose vertex places the new species in *Idioscopus*.

4. Idioscopus lalithae sp. nov. Figs. 22–32

Pale brown species with or without black markings. Posterior and lateral borders of vertex and most of face ochraceous to greenish ochraceous; females with a black round spot laterodorsad of each ocellus; a dark female specimen with a median brown area on frontoclypeus and clypellus black (Fig. 23). Eyes black. Pronotum in darker specimens (Holotype ♂, 2 ♀ ♀ and 1 ♀ paratypes) with a posterior submarginal black band. Scutellum with two basal triangular spots and two spots on median impressed line brownish; in darker specimens these spots black, apical half ochraceous. Forewing brownish with either concolourous veins or with dark brown prominent veins. Legs and abdominal sternites greenish ochraceous, tergites medially dark brown.

Face wider than long. Clypellus more than twice as wide at apex as at base. Lorum tumid, frontoclypeus elevated, gena rugose face dorsad of ocelli and vertex rugose. Vertex more or less of uniform length. 2 to 2.4 times as broad between eyes as its median length. Pronotum 1.3 to 1.5 times wider than long. Scutellum longer than pronotum, with a median impressed line. Forewing with four apical and three anteapical cells, the outer anteapical cell being 1/3 as long as median anteapical cell; two cross veins between M and Cu.

Male genitalia : Seventh sternum caudally produced and anteriorly with a pair of lobe-like apodemes. Pygofer elongate, narrow, much narrower than the width of the male plate, caudally rounded and with cephalic apodemes. Anal collar simple without process. Male plates broad, longer and



Figs. 22–32 *Idioscopus lalithae* sp. nov 22. Head and thorax; 23. Face; 24. Male pygofer; 25. Male plate; 26. Anal collar and anal segment; 27. Connective and style, dorsal view; 28. Aedeagus, lateral view; 29. Apodeme at the base of abdomen of male; 30. Female genitalia; 31. Second valvula; 32. First valvula.

wider than pygofer, broadest at middle apically truncate with long hair like setae, basal sclerite of male plate elongate, plates held almost vertically. Style with a very short anterior part, its body robust and more or less rectangular, apical lobe prominent with 3 to 5 long setae, apophysis elongate, laterally curved with inner margin serrate and apex with expanded hyaline lobes (Fig. 27). Connective T–shaped. Aedeagus U–shaped, with well developed dorsal apodeme, shaft elongate apically recurved into a strong hook beyond gonopore and laterally compressed.

Female genitalia : Hindmargin of seventh sternite caudally convexly rounded. Ovipositor extending well beyond pygofers. First valvulae thin with a large area occupied by parallel striae, apically pointed (Fig. 32). Second valvulae with serrated cutting edge forming a strong triangular blade (Fig. 31).

Measurements : Male 5.72 (5.7–5.86) mm in length and 1.8 (1.78–1.83) mm in width; female 6.14 (5.8–6.43) mm in length and 1.9 (1.9–2.0) mm in width.

Holotype ♂ INDIA : KERALA, Thekkady, 26. iii. 1977, C. A. Viraktamath Coll., and **Paratypes** 5 ♂♂ with same data. 5 ♂♂ and 4 ♀♀ paratypes with same locality but collected on 27. iii. 1977 by C. A. Viraktamath (3 ♂♂ and 1 ♀), Shashidhar Viraktamath (2 ♂♂ and 2 ♀♀), and B. Mallik (1 ♀).

Remarks : In many respects *I. lalithae* deserves an erection of a new genus as it forms an atypical member of the *Idioscopus*. The large, well sclerotized broad male plates, narrow elongate pygofer, absence of anal collar process, peculiar style, and triangular blade-like first pair of valvulae, tumid lora and elevated frontoclypeus distinguish this species from all other known species of *Idioscopus*. Proposal of a new genus for this species is constrained till some more species related to this become available.

KEY TO THE INDIAN SPECIES OF *IDIOSCOPUS* BAKER

1. Thickly punctate species with tagmina anteriorly punctate and posteriorly subreticulate ..... *I. subopacus* (Motschulsky)

—Species not punctate, tegmina with normal venation 2

2. Third apical cell of forewing with a black spot 3

—Third apical cell of forewing without a black spot 5

3. Aedeagal shaft with a pair of ventrally directed processes; scutellum without black spots, clavus uniformly smoky-brown ..... *I. pretiosus* Viraktamath

—Aedeagal shaft with an unpaired anterior process; scutellum with a basal pair of triangular black spots; clavus either yellowish-green or smoky with a lemon-yellow marking 4

4. Pygofer with a ventral process; aedeagal shaft sinuate, its apex attenuated; clavus yellowish green ..... *I. decoratus* Viraktamath.

—Pyfoger without a ventral process, aedeagal shaft not sinuate, its apex with a ventrally directed short process; clavus smoky with a lemon yellow markings ..... *I. bellus* Viraktamath

5. Male plates broader than the width of the pygofer and well sclerotized, anal collar process absent; cutting edge of first valvulae traingularly expanded ..... *I. lalithae* sp. nov.

—Male plates weekly sclerotized much narrower than the width of pygofer, anal collar process well developed; cutting edge of the first valvula normal 6

6. Face and vertex with round black spots, otherwise conspicuously marked with black or brown 14

—Face and vertex uniformly ochraceous or lemon yellow or yellowish green, without black spots or irregular black or brown markings; clypellus black in some species.....7

7. Aedeagus with processes.....8

—Aedeagus without processes.....11

8. Aedeagus with two processes.....9

—Aedeagus with four processes.....10

9. Head, pronotum, scutellum and clavus bright yellowish green; aedeagal shaft with lateral lamellate expansion and with ventrally directed elongate processes arising on anterior apical margin.....*I. virescens* Viraktamath

—Head, pronotum and scutellum ochraceous; aedeagal shaft without lamellate expansion, a pair of subapical processes arising on posterior margin directed ventrally and their apical half abruptly bent and directed posteriorly..... *I. bimaculatus* (Pruthi)

10. Pygofer with a ventral short process; anal collar process broad at base and then narrowed distally..... ..... *I. nigroclypeatus* (Melichar) (Males)

—Pygofer without a ventral process; anal collar process of uniform width..... ..... *I. scutellatus* (Distant)

11. Aedeagal shaft sinuately curved.....12

—Aedeagal shaft evenly curved.....13

12. Head, pronotum and scutellum, yellowish green, a large discal spot on pronotum and basal half of scutellum black; anal collar process slender and L-shaped, apophysis of the style without a tooth..... ..... *I. spectabilis* Viraktamath

—Head and pronotum immaculate, lemon yellow, scutellum with two brown basal triangular spots, anal collar process broad, almost straight, apically attenuated, apophysis of style with a preapical tooth..... ..... *I. dworakowskae* Viraktamath

13. Aedeagal shaft apically attenuated, without a lateral furrow, dorsal apodeme enlarged, anal collar distally bifurcate and C-shaped; Scuttellum without black spots..... ..... *I. indicus* sp. nov

—Aedeagal shaft robust, short, laterally furrowed, anal collar process slender and apically attenuated: scutellum with two black spots. ..... *I. robustipennis* sp. nov

14. Face irregularly marked with brown or black patches without well defined black spots.....15

— Face with one or more small round black spots near upper margin.....16

15. Style with anterior portion longer than posterior; apodeme of aedeagus not keeled. ..... *I. incertus* (Baker)

—Style with anterior portion shorter than posterior; apodeme of aedeagus keeled..... ..... *I. niveosparsus* (Lethierry)

16. Face and/or pronotum with fuscous or black markings.....17

—Face uniformly yellowish or ochraceous with small dark spots well defined; pronotum unspotted.....19

17. Clypeus with lateral margins and contiguous areas of gena heavily infuscated; pronotum with four black spots, one near each lateral angle and two on anterior margin; female seventh sternite almost straight with a median concavity..... ..... *I. fasciolatus* (Distant)

—Clypeus and pronotum not as above; female seventh sternite convex with or without a median excavation.....18

18. Clypeus immaculate; pronotum with two black round spots on anterior margin; pygofer with a ventral elongate process, style with a subapical ventral process, aedeagus with two short anterior and two long posterior subapical processes..... *I. webbi* sp. nov

—Clypeus with a central large black or brown spot; pronotum with two broad black patches on anterior margin; pygofer without subapical process but with a tuft of apical hairs; aedeagus with four subapical processes arising on posterior margin..... ..... *I. shillongensis* Viraktamath

19. Face with a single black spot between ocelli.. ..... *I. unimaculatus* (Melichar)

—Face with two black spots on upper part of face.....20

20. Clypellus entirely black..... .....*I. nigroclypeatus* (Melichar) (females)

—Clypellus ochraceous or black on its apical 1/2 or 3/4.....21

21. With two minute dots high on the face one near each eye; style with an apical tuft of hairs and ventrally serrated; two pairs of processes to aedeagal shaft subequal..... ..... *I. confuscous* (Pruthi)

—With two large spots on vertex; style without a tuft of hairs; ventrally not serrate; processes of aedeagus unequal in length.....22

22. Apex of aedeagal shaft rather pointed; apex of style pointed..... ..... *I. clypealis* (Lethierry)

—Apex of aedeagal shaft knob-like; apex of style broad and with small round lobe..... ..... *I. nagpurensis* (Pruthi)

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THREE NEW DROSOPHILIDS (DIPTERA : DROSOPHILIDAE) FROM NORTH EAST INDIA

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Three new species, *Curtonotum neoangustipennis*, *Liodrosophila okadai* and *Leucophenga shillongenis* representing three different genera of the family Drosophilidae, are described from Ramam, Darjeeling and Shillong, Meghalaya. A list of Indian species of Drosophilidae (excluding *Drosophila* species) is also provided.

(*Key words:* **new** *Drosophila*)

Recent studies on the systematics of Indian drosophilid species have accumulated considerably large data; however, these studies in India have been concentrated more on the genus *Drosophila* rather than on other allied genera of the family Drosophilidae. Gupta (1974) made an attempt to provide a comprehensive review of information regarding the Indian species of Drosophilidae, exclusive of the genus *Drosophila*. Since then many species have been added to the list of Indian Drosophilidae (Reddy and Krishnamurthy, 1973-74; Vaidya and Godbole, 1973, 1976; Singh and Gupta, 1974; Sajjan and Krishnamurthy, 1975). The present paper deals with the description of three new species belonging to three different genera, viz., *Leucophenga*, *Curtonotum* and *Liodrosophila*, out of which the latter two are recorded for the first time from India.

Genus *Curtonotum* Macquart

Curtonotum Macquart 1843, Mem. Soc. R. Sci. Agric. Lille, 1842: 350 (1843: 113). Type: *Musca gibba* Fabricius, by monotypy.

Curtonotum, correction. *Diplocentra* Loew 1862, Z. Ent. Breslau, 13:13 (1859) (unjustified n. name for *Curtonotum* Macquart *Parapsinota* Duda 1924, Arch. Naturgesch A, 90 (3): 177. Type: *Drosophila angustipennis* De Meijere, by monotypy.

Two pairs of orbital bristles, one proclinate and one reclinate, and a minute seta in front or near base of the proclinate orbital; front broad in both sexes; wings fuscous; front femur with a row of short, thick anteroventral spines approximately on distal one half.

1. Curtonotum neoangustipennis sp. nov.

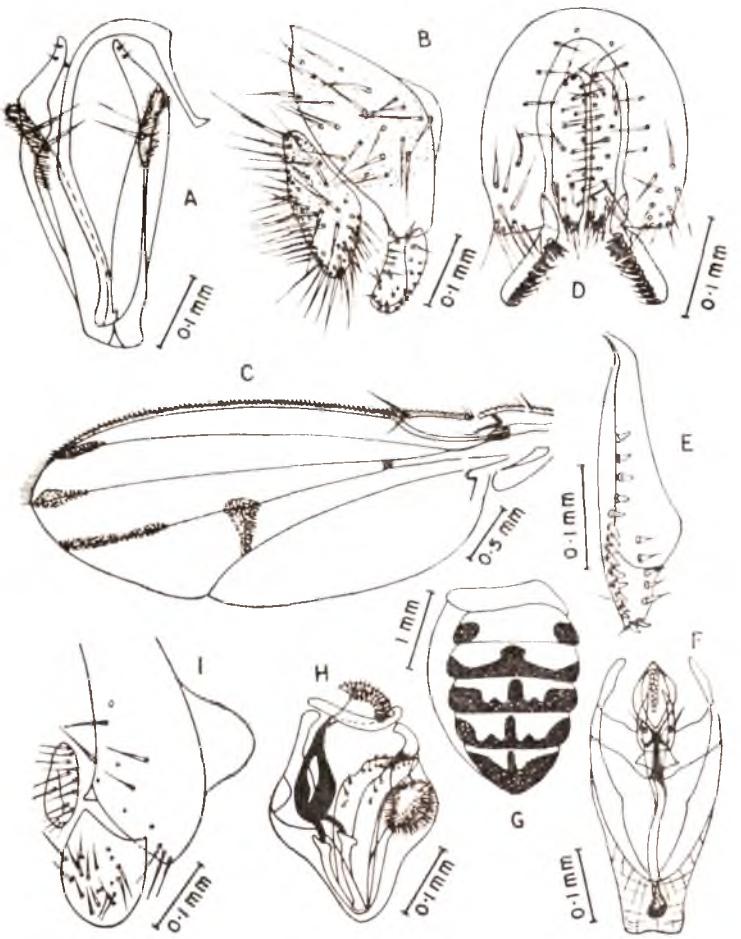
Male and Female: Arista with about 7-9 dorsal and 5-6 ventral branches in addition to the terminal fork. Antennae with second segment dark brown; third segment little darker. Frons including ocellar triangle dark brown, frons broad. Aterior reclinate orbital very minute, proclinate about three fourths the length of the posterior reclinate. Second oral thin, about one third the length of vibrissa. Palpi dark brown with few marginal setae. Carina brown, low. Face and cheek orange brown, greatest width of cheek about one ninth the greatest diameter of eye. Clypeus black. Eyes dark red with blackish tint.

Acrostichal hairs regular, in eight rows. Anterior scutellars strongly divergent,

Prescutellars present. Anterior dorsocentrals about two thirds the length of the posterior dorsocentrals; distance from anterior dorsocentral to posterior dorsocentral about two-thirds the distance between two anterior dorsocentrals. Mesonotum and scutellum unicolourous, blackish. Thoracic pleura brownish black. Legs greyish yellow, coxa with 6-7 black bristles at base, forefemora brownish and with a row of 8 short black spine like teeth near base, of which one is twice the length of others. Preapicals on all three tibiae.

Wings: (Fig. 1C) dusky; both cross veins clouded and 2, 3, 4th longitudinal veins with elongated black patches at apices. Approximate indices: C-index 6.1; 4 V-index 1.17; 4 C-index 0·36, 5 X-index 1·34. Two unequal bristles at the apex of first costal section; heavy bristles on about basal one ninth of the third costal section. Halteres white.

Abdominal tergites dark brown to black. Length of male body (from 1 male) = 4.61 mm.



(A–C): *Curtonotum neoangustipennis* sp. nov. A–phallic organs; B–periphallic organs; C–wing. (D–F): *Liodrosophila okadai* sp. nov. D–periphallic organs; E–egg guide; F. Phallic organs. (G–I): *Leucophenga shillongensis* sp. nov. G–male abdomen; H–phillic organs; I–periphallic organs.

Periphallic organs (Fig. 1B): Genital arch brown, pubescent, large, somewhat broadened in middle; upper margin with about 21 bristles. Clasper longer than broad, with about 11 fine bristles and several setae. Anal plate elliptical, pubescent, and with about 57 large bristles.

Phallic organs (Fig. 1A): Aedeagus large, curved and narrowing apically. Anterior parameres large, with apical sensilla. Ventral fragma narrow.

Holotype ♂, INDIA: WEST BENGAL, Ramam, Darjeeling district, May 1977 (Dwivedi and Gupta). **Paratypes**: 1 ♂, 1 ♀, same locality and collectors as holotype. Deposited in the Department of Zoology, Banaras Hindu University, Varanasi, India.

Distribution: India.

This species is somewhat related to *Curtonotum angustipennis* (De Meijere) but differs from it in having clasper while it is absent in the latter species.

Genus *Liodrosophila* Duda.

Liodrosophila Duda 1922, Arch. Naturgesch A, 88 (4): 153 Type: *Camilla coeruleifrons* De Meijere, Java; Okada 1956, Syst. Study Dros. Japan, 57; HARRISON 1954, Trans. R. ent. Soc. London, 105: 113; Wheeler and Takada 1964, Insects of Micronesia 14 (6): 222.

Small species; body shiny, often with metallic colours; postverticals and anterior reclinate orbitals minute; acrostichal hairs in 2-8 rows, forefemur often with a row of short black spinnules.

2. Liodrosophila okadai sp. nov.

Male and female: Arista with about 3-4 dorsal and 2 ventral branches in addition to the terminal fork. Antennae with second segment dark brown; third segment pale brown in male, little darker in female. Frons including ocellar triangle glossy brownish black. Anterior reclinate orbital minute, proclinate about two thirds the length of the posterior reclinate. Second oral thin, about half the length of vibrissa. Palpi orange brown, with one long prominent apical seta. Carina pale, narrow, high. Face and cheek reddish brown, greatest width of cheek about one eighth the greatest diameter of eye. Clypeus black. Eyes red.

Acrostichal hairs regular, in six rows. Anterior scutellars convergent. Anterior dorsocentrals about two thirds the length of the posterior dorsocentrals; distance from anterior dorsocentral to posterior dorsocentral half the distance between two anterior dorsocentrals. Mesonotum and scutellum unicolourous, shining black. Thoracic pleura brownish black. Legs pale yellow, forecoxae and femora black in both sexes, inner side of forefemur with a row of about 14–15 spinnules, preapicals on all three tibiae; apicals on first and midtibiae.

Wings: Hyaline. Approximate indices: C-index 2.22; 4 V-index 2.0; 4 C-index 1.15; 5 X-index 1.68. Two bristles at the apex of first costal section; heavy bristles on about basal half of the third costal section. Halteres whitish.

Abdominal tergites uniformly shining black.

Average length of male body (from 2 males): 2.46 mm.

Average length of female body (from 2 females): 2.71 mm.

Periphallic organs (Fig. 1D): Genital arch dark brown, narrow, with about 17 marginal bristles. Clasper narrow and elongated, with about 13–14 black teeth arranged in a straight row and out of them 4-5 upper teeth slightly more thicker and larger, and

with 7 setae ventrally. Anal plate yellowish brown, oblong, with several large bristles.

Phallic organs (Fig. 1F): Aedeagus straight, somewhat swollen subapically. Basal apodeme nearly twice as long as aedeagus. Hypandrium with a pair of small submedian spines. Ventral fragma longer than broad.

Egg guides (Fig. 1E): Lobe yellowish brown, narrowing apically, with 16 marginal brown teeth and 5 discal yellow teeth. Basal isthmus narrow and short.

Holotype ♂, INDIA: WEST BENGAL, Ramam, Darjeeling district, May 1977 (Dwivedi and Gupta). **Paratypes**: 1 ♂, 2 ♀♀, same locality and collectors as holotype. Deposited in the Department of Zoology, Banaras Hindu University, Varanasi, India.

Distribution: India.

Genus *Leucophenga* Mik

Leucophenga Mik 1886, Wiener Ent. Zeitung 5:317. Type: *Drosophila maculata* Dufour, Europe; Duda 1924, Arch. Naturgesh A, 90 (3): 185.

Arista plumose, with numerous branches, acrostichal hairs in numerous rows; prescutellars well differentiated; all three orbital bristles strong; posterior reclinate arising nearer to inner vertical than to proclinate; discal and second basal cells confluent; third costal section with thorn like spines.

3. **Leucophenga shillongensis** sp. nov.

Male and female: Arista with about 5-6 dorsal and 2-3 ventral branches in addition to the terminal fork. Antennae with second segment dark brown; third segment yellowish. Frons including ocellar triangle reddish brown, anteriorly yellowish. Anterior reclinate minute, proclinate orbitals nearly equal to the posterior reclinate. Second oral thin, about one fourth the length of vibrissa. Palpi yellow, tip brownish, with one large apical and 3-4 marginal setae. Carina brown, low. Face and cheek brown, greatest width of cheek about one ninth the greatest diameter of eye. Clypeus orange brown. Eyes bright red.

Acrostichal hairs irregular, in ten rows. Anterior scutellars divergent. Prescutellars present. Anterior dorsocentrals about half the length of the posterior dorsocentrals; distance from anterior dorsocentral to posterior dorsocentral about one third the distance between two anterior dorsocentrals. Mesonotum reddish brown. Scutellum little darker. Thoracic pleura pale yellow, sternopleural plate brown. Sterno-index about 0.75. Legs straw yellow, preapicals on all three tibiae; apicals on mid- and hindtibiae.

Wings: Clear. Approximate indices: C-index 3.21; 4 V-index 1.8; 4 C-index 0·87; 5 X-index 1.23. Two bristles at the apex of first costal section; heavy bristles on about basal two thirds of the third costal section. Halteres whitish yellow.

Abdominal tergites (Fig. 1G) yellow with black spots as follows: 1T yellow; 2T with two lateral black spots; 3T-6T with caudal bands projecting laterally and medially.

Average length of male body (from 3 males): 3·24 mm.

Average length of female body (from 2 females): 3.5 mm.

Periphallic organs (Fig. 1I): Genital arch pale yellow, broadly truncate at lower end, with about 14 marginal bristles. Clasper quadrate, with about 21 long setae. Anal plate small, with about 15 bristles.

Phallic organs (Fig. 1H): Aedeagus black, bifurcated basally and somewhat swollen apically. Anterior parameres long, with few

sensilla on upper half. Ventral fragma triangular.

Holotype ♂, INDIA: MEGHALAYA, Motinagar forest, Khasiya Hill, Shillong district, November 1976 (Dwivedi and Gupta). **Paratypes**: 4 ♂♂, 2 ♀ ♀, same locality and collectors as holotype. Deposited in the Department of Zoology, Banaras Hindu University, Varanasi, India.

Distribution: India.

LIST OF INDIAN DROSOPHILIDAE (EXCLUDING *DROSOPHILA* SPECIES)

Genus *Gitonides* Knab.

1. *perspicax* Knab, 1914.

Genus *Mycodrosophila* Oldenberg

2. *gratiosa* (De Meijere, 1911).

Genus *Leucophenga* Mik

3. *albicincta* (De Meijere, 1908).
4. *flavicosta* Duda, 1926.
5. *guttiventris* (De Meijere, 1911).
6. *interrupta* Duda, 1924.
7. *neoangusta* Vaidya and Godbole, 1976.
8. *shillongensis* sp. nov.
9. *subpollinosa* De Meijere, 1914.

Genus *Paraleucophenga* Hendel

10. *invicta* (Walker, 1857).

Genus *Scaptomyza* Hardy

11. *graminum* (Fallén, 1823).
12. *pallida* (Zetterstedt, 1847).

Genus *Chymomyza* Czerny

13. *vaidyai* Okada, 1976: Nom. nov. for *Chymomyza pararufithorax* Vaidya and Godbole (1973) Drosoph. Inf. Serv., 50:71.

Genus *Microdrosophila* Malloch

14. *purpurata* Okada, 1956.

Genus *Stegana* Meigen

15. *subexcavata* Vaidya and Godbole, 1976.

Genus *Lissocephala* Malloch

16. *sabroskyi* Wheeler and Takada, 1964.

Genus *Hypselothyrea* De Meijere

17. *varanasiensis* Gupta, 1974.

Genus *Sinophthalmus* Coquillett Syn. of subgenus *Erima* Kertész of genus *Amiota* Loew. Ref. Okada, 1971. Kontyû 39:83.

18. *pictus* Coquillett, 1904.

Genus *Curtonotum* Macquart

19. *neoangustipennis* sp. nov.

Genus *Zaprionus* Coquillett

20. *indiana* Gupta, 1970.
21. *paravittiger* Godbole and Vaidya, 1972.
22. *striata* Sajjan and Krishnamurthy, 1975.

Genus *Liodrosophila* Duda

23. *okadai* sp. nov.

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NEW APHIDS (HOMOPTERA : APHIDIDAE) FROM SIKKIM, NORTHEAST INDIA

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Two new aphid species viz. *Taiwanaphis dineni*, sp. nov. belonging to subfamily callipterinae and *Vesiculaphis sikkimensis*, sp. nov. belonging to subfamily Aphidinae are described from Sikkim for the first time. A key to the species of the Genus *Taiwanaphis* is also included.

(*Key words:* **new aphids from sikkim**)

Examination of aphid samples collected in Sikkim during the period 1975 resulted in the finding of 2 new species described hereunder.

Materials of the new species are deposited in the collections of Entomology Laboratory, Department of Zoology, Calcutta University.

1. Taiwanaphis dineni, sp. nov

Alate viviparous female (Fig. 1): Body 1.80—1.95 mm long with 0.80—0.93 mm as its maximum width. Head pale brown but brown to dark brown around lateral and median ocelli; dorsal cephalic hairs stout, sparse, moderately long and with acute to acuminate apices. Antennae 6 segmented, about 0.56—0.63 × body; segments I, II and base of III dark brown, rest of flagellum pale; segments I and II scabrous; flagellum gradually distinctly imbricated apicad; segment III swollen on basal 1/3 portion and then abruptly narrowed, with transversely elongate and irregularly arranged nonciliated 30-35 secondary rhinaria, processus terminalis about 0.53 × base of last antennal segment; flagellar hairs sparse, short and with acuminate to blunt apices, the longest one on segment III about 0.31—0.40 × basal diameter of the segment. Eyes large with prominent ocular tubercles. Rostrum hardly reaches midcoxae; ultimate rostral segment short and blunt, about 0.70—0.77 × second joint of hindtarsus and with 2 secondary hairs. Abdominal dorsum pale with segmentally arranged 2-4 hairs bearing marginal tuberculate sclerites on tergites 1-6, these becoming darker posteriorad but tubercles on posterior segment less developed; dorsal hairs moderately long, with blunt to acuminate apices except on 8th tergite where these are with acute apices, longest hair on anterior tergites about 0.55 × basal diameter of antennal segment III, those on 7th tergite about 0.55 × and on 8th tergite about 0.44 × the mentioned diameter; tergites 7 and 8 with 4 and 2 hairs respectively. Siphunculi brown, cone shaped, with two hairs appended to the base, much wider than long, striate, with distinct apical flange. Cauda brown, elongate, widest at base and tapering at apex, with a median constriction and bearing 13-14 hairs. Subanal plate distinctly bilobed. Legs brown; apices of tibiae and entire tarsi spinulose; apical 1/3 of tibiae with numerous short and stouter hairs but rest of tibiae with long and sparse hairs; first tarsal segments with 3 ventral and 2 dorsal hairs. Wing veins clouded;

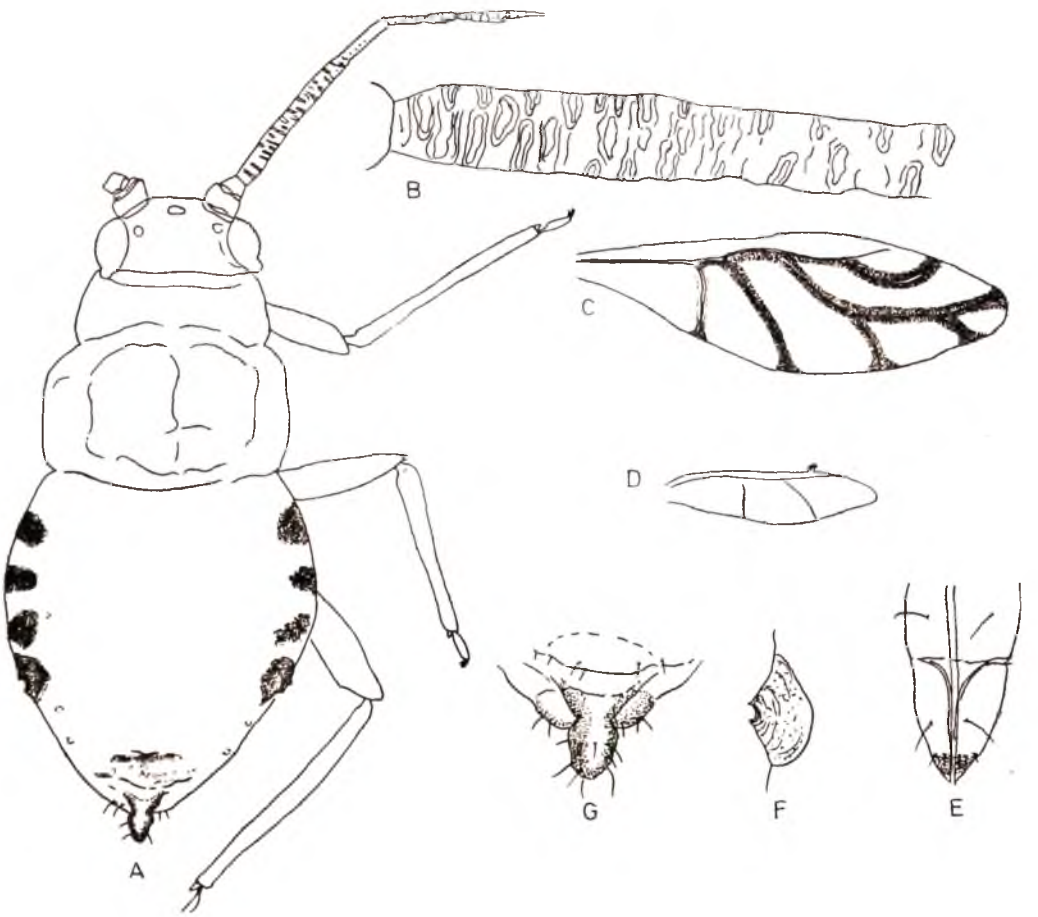

Fig. 1. *Taiwanaphis dineni*, sp. nov. Alate viviparous ♀. A. Body without wing; B. Part of antennal segment III; C. Forewing; D. Hindwing; E. Part of rostrum; F. Siphunculus; G. Cauda.

media of forewing twice-branched; hindwing with 2 oblique veins.

Measurements of the holotype in mm: Length of body 1.94, width 0.95; antenna 1.15, segments III: IV: V: VI 0.44: 0.16: 0.17: (0.15+0.08); ultimate rostral segment 0.06; second joint of hindtarsus 0.09; diameter of siphunculular pore 0·02; cauda 0.18.

Alate male: Body about 1.76 mm long with 0.69 mm as maximum width. Antenna 0.71 × body; 60, 8, 8 and 3-4 ciliated transversly elongate secondary rhinaria on segments III, IV, V and base of segment VI respectively; processus terminalis about 0.53 × base of segment VI. Ultimate rostral segment about 0.74 × second joint of hindtarsus. Abdominal venter with spinulose striae. Siphuncular pore slightly smaller than in alatae. Cauda with 12 long hairs. Femora spinulose ventrally. Other Characters as in alate viviparous female.

Measurements of the alate male in mm: Length of body 1.76, width 0.69; antenna

1.26, segments III: IV: V: VI 0.51: 0.20: 0.18 (0·18+0.09); ultimate rostral segment 0.06; second joint of hindtarsus 0.08; cauda 0.13.

Apterous oviparous female: Body about 1.62 mm long with 0.83 mm as its maximum width. Head marginally brown and rugose. Antennae 4-segmented, about 0.61 × body; segments I, II and processus terminalis brown and rest pale; bearing a few short, sparse, bluntish hairs; processus terminalis short, about 0.62 × base of last antennal segment; secondary rhinaria absent; primary rhinaria ciliated. Ultimate rostral segment about 0.60 × second joint of hindtarsus and without any secondary hair. Abdomen pale; dorsum with a few scattered muscle-plate-like structure besides paired lateral pale brown scabrous sclerites bearing 2-4 fine hairs; post-siphuncular segments with brown transverse bands. Cauda with a knobbed apex and a median constriction. Femora and tibiae pale excepting dusky bases and apices; middle of tibiae narrow but basal and apical portions swollen; apical 0.33 portion of tibiae with many short and long spines but those on apex thinner than in alatae; hindtibiae with many pseudo-sensoria like structure.

Measurements of one apterous oviparous female in mm: Length of body 1.62, width 0.83; antanna 0.70, segments III: IV 0.40: (0.10 + 0.08); ultimate rostral segment

Fig. 2. *Taiwanaphis dineni*, sp. nov. Apterous oviparous ♀ (A–F) and alate ♂ (G–J). A. Body; B. Part of rostrum; C. Antenna; D. Siphunculus; E. Cauda; F. Hindtibia; G. Antenna; H. Part of rostrum; I. Cauda; J. Siphunculus.

0.06; second joint of hindtarsus 0.09; cauda 0.16.

Holotype: Alate viviparous ♀, INDIA: SIKKIM: Tinbong *C* 1000 m, 10. x. 1975, from an unidentified plant of N.O Combretaceae; coll. P. K. Mandal, **Paratype:** 25 alate viviparous ♀♀, 1 alate ♂, 3 apterous oviparous ♀♀ and 12 nymphs, collection data same as for the holotype.

Remark: The genus *Taiwanaphis* was described by Takahashi in (1934) from Taiwan (Formosa) with *T. decaspermi* collected on a plant of Myrtaceae as the type. Later, Ghosh, A.K., Banerjee, H. and Raychaudhuri, D. N. (1971) while describing *T. randiae* collected on a plant of Rubiaceae from Arunachal Pradesh (NEFA) distinguished it from *T. decaspermi* by the presence of more secondary rhinaria (32-46), processus terminalis nearly as long as the base of last antennal segment, marginal sclerites on abdominal dorsum and also by different host association (Rubiaceae). This new species *T. dineni* becomes the third species in the genus being collected on a plant of Combretaceae at Sikkim. Morphologically this new species appears more close to *T. randiae* because of presence of more (30-35) secondary rhinaria and marginal tuberculate hair bearing sclerites on abdominal dorsum and also in the general facies. But *T. dineni* differs from *T. randiae* in having much shorter processus terminalis (0.53×) in comparison to base of last antennal segment, more caudal hairs (13-14) and longer hairs (15μ) on anterior abdominal tergites. Further as pointed out before the two species *T. randiae* and *T. dineni* differ in host association.

However, collection of viviparous and oviparous females along with alate male from one host plant at the same time suggests

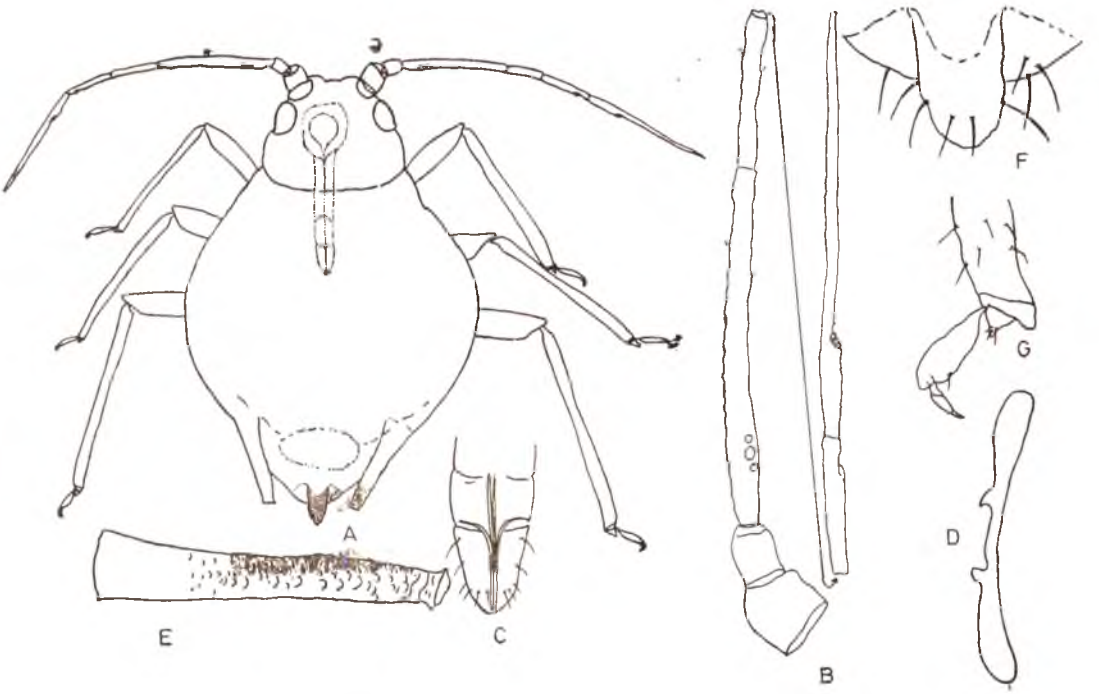

Fig. 3. *Vesiculaphis sikkimensis*, sp. nov. Apterous viviparous ♀. A. Body; B. Antenna; C. Part of rostrum; D. Mid-thoracic furca; E. Siphunculus; F. Cauda; G. Hindtarsus.

host restriction for the species and the possibility of its completion of holocyclic mode of life-cycle in Sikkim climate. It may be pointed out here that this is the first report of the find of sexuals for the members of this genus.

However, the three species of the genus *Taiwanaphis* as stated above can easily be separated by the following key.

KEY TO THE SPECIES OF *TAIWANAPHIS*

1. Secondary rhinaria on 3rd antennal segment 11–14; on plates of Myrtaceae..... ..... *decaspermi* Takahashi

—Secondary rhinaria on 3rd antennal segment 30–46; on plants other than Myrtaceae.....2

2. Processus terminalis about 0.90 × base of last antennal segment; cauda with 9 hairs; on plants of Rubiaceae..... ....*randiae* Ghosh, Banerjee and Raychaudhuri

—Processus terminalis about 0.54 × base of last antennal segment; cauda with 13–14 hairs; on plants of Combretaceae..... .....*dineni*, sp. nov

2. Vesiculaphis sikkimensis, sp. nov.

Apterous viviparous female: Body about 1.25—1.56 mm long with 0.76—0.98 mm as maximum width. Head weakly spinulose; dorsal cephalic hairs sparse, 'myzine' type; lateral frontal tubercles well developed, scabrous on inner margin, median frontal prominence ill developed. Antennae 6—segmented, about 0 67—0.74 × body, brown excepting segment III which is paler and with 1—3 secondary rhinaria; primary rhinaria sunken and ciliated, flagellum gradually more distinctly imbricated towards apex; longest hair on antennal segment III about 0.42—0.60 × the basal diameter of segment III; processus terminalis about 2.43—2.58 × the base of segment VI. Rostrum extends beyond midcoxae; ultimate rostral segment of normal shape, about 1.03—1.15 × the second segment of hindtarsus, with 4 secondary hairs. Thoracic and abdominal tergites, pale brown and wrinkled, with faint brown patches arranged spinopleurally and marginally on tergites 1–7, tergite 8 with a dark brown transverse band. Mesothoracic furca sessile. Dorsal abdominal hairs short, longest one on anterior tergites about 0.28—0.57 × the basal diameter of segment III; longest hair on tergite 7 about 0.50—0.85 × and those on tergite 8 adout 1.28—1.51 × the mentioned diameter. Siphunculi dark, imbricated with thick flange, cylindrical, about 0.19,—0.22 × body and about 1.81—2.27 × tongue shaped cauda bearing 4-5 hairs. Femora and apical half of tibiae brown and rest paler; first tarsal chaetotaxy 3, 3, 3.

Measurements of the holotype in mm:

Length of body 1.56, width 0.98; antenna 1.11, Segments III: IV: V: VI 0.30: 0.14: 0.13: (0.10+0.26); ultimate rostral segment 0.10; second joint of hindtarsus 0.09; siphunculus 0.34; cauda 0.15.

Alate viviparous female: Body about 1.58—1.66 mm long. Dorsum of head smooth with frons straight and smooth. Antennae about 1.09 × body; processus terminalis about 2.59—2.69 × base of segment VI; segment III with 15-17 secondary rhinaria on outer margin distributed throughout the length. Ultimate rostral segment about 1.15—1.19 × second segment of hindtarsus. Abdominal dorsum pale with marginal coloured patches on tergites 1–6 beside scattered small spinopleural sclerites, tergite 7 with a well developed spinopleural patch beside marginal ones, tergite 8 with a median brown patch; dorsal hairs moderately long with acuminate apices; longest hair on 7th tergite nearly equal to the basal diameter of segment III. Cauda bears 4 hairs. Femora with spinulosity on inner margin. Wing

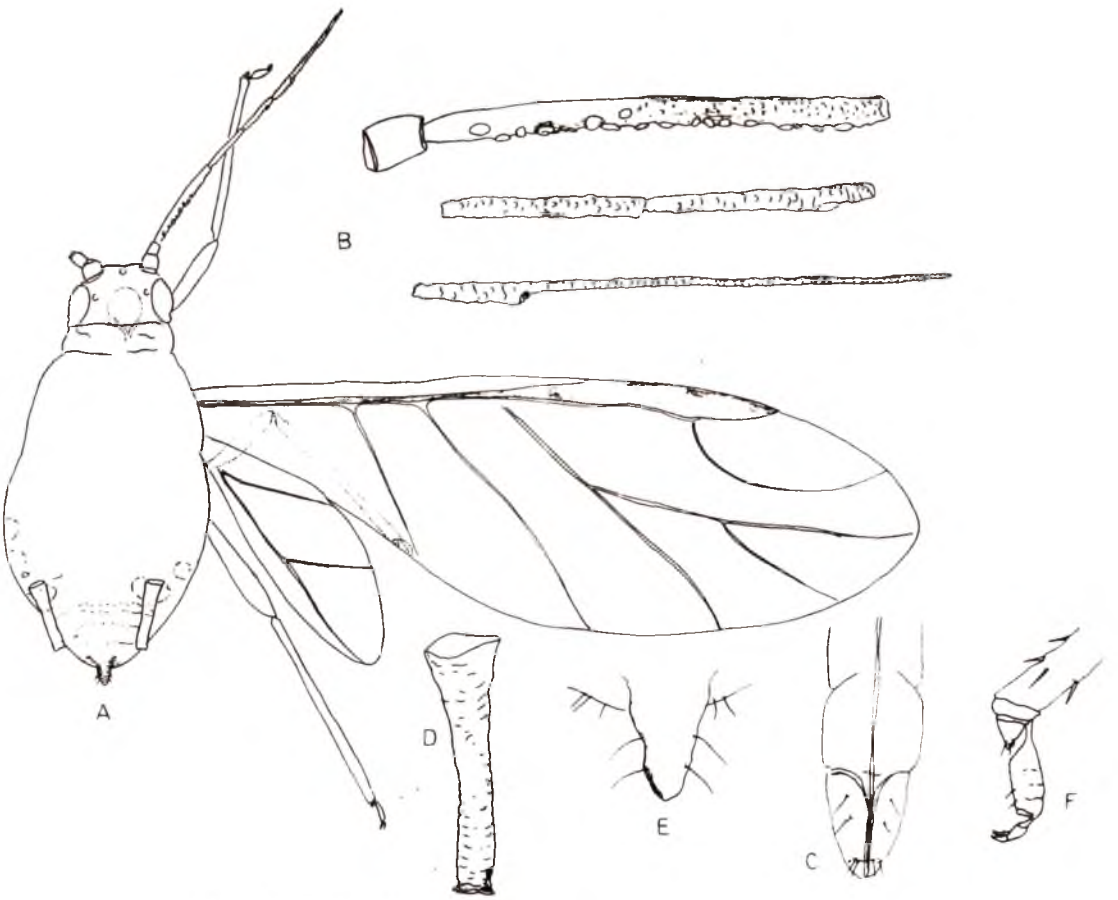

Fig. 4. *Vesiculaphis sikkimensis*, sp. nov. Alate viviparous ♀. A. Body; B. Antenna; C. Part of rostrum; D. Siphunculus; E. Cauda; F. Hindtarsus.

venation normal, veins darker, otherwise as in apterae viviparae.

Measurements of one alate viviparous female in mm :

Length of body 1.58, width 0.72; antenna 1.22, segments III: IV: V: VI 0.31: 0.16: 0.15: (0.11 × 0.29); ultimate rostral segment 0.09, second segment of hindtarsus 0.08; siphunculus 0.27; Cauda 0.12.

Holotype: Apterous viviparous ♀. INDIA: SIKKIM: Namchi *C* 1666 m from *Carex* sp. (cyparaceae), 22. x. 1975, Coll. P. K. Mandal; **Paratype:** 8 apterous and 2 alate viviparous ♀♀ 5 apterous and 2 alatoid nymphs, collection data same as for the holotype; 6 apterous viviparous ♀♀, 7 apterous and 1 alatoid nymph from *Carex filicosa* (Cyperaceae), Sanklang *C* 1000 m. 3. xi. 1974, Coll. P. K. Mandal.

Biological notes : Brownish insects were collected from the inflorescence of the host plant. No ant was noticed in association.

Remark: Following Miyazaki (1971) and Ghosh *et al.* (1976) this species in having smooth or faintly scabrous head, antennae

6 segmented, antennal segment III with secondary rhinaria in apterae and pale abdominal dorsum though does not appear to be typical for the genus *Vesiculaphis* it cannot be accommodated in any other genus. So at present it is included in this genus. However, availability of more such specimens in future will help in determining the generic status of this species.

Acknowledgements:—The authors are thankful to Indian Council of Agricultural Research, New Delhi for partly financing the work and to the Head of the Department of Zoology, Calcutta University for laboratory facilities.

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BRIEF COMMUNICATION

INFLUENCE OF SOME SPECIFIC TIME- AND AGE-RELATED MATING SCHEDULES ON OVIPOSITION AND EGG FERTILITY IN *CORCYRA CEPHALONICA* STAINT. (LEPIDOPTERA : GALLERIDAE)

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(*Received 12 December 1978*)

Mating in *Corcyra cephalonica*, which can take place between males or females of even 6 days old and newborn adults of the opposite sex, generally occurs at night within 2 days of adult emergence. Increment in oviposition and egg fertility are noticed only when freshly eclosed males and females copulate between 22.30 and 2.30 hours of a normal day-night rhythm.

(*Key words:* **mating time and age, oviposition, egg fertility,** *Corcyra cephalonica*)

Notwithstanding availability of appreciable amount of useful information on various aspects of nutrition (review by BHATTACHARYA & PANT, 1965; SRIVASTAVA & KRISHNA, 1976, 1978) of the rice moth *Corcyra cephalonica*—a major pest of stored commodities–our knowledge concerning the reproduction of this insect based on direct experimental studies is unfortunately limited (KRISHNA & NARAIN, 1976). So studies on egg laying and hatchability of eggs in relation to certain time– and age–bound matings were undertaken.

Male and female moths were individually reared in the laboratory from egg stage on a diet composed of powdered 'jwar' (*Sorghum vulgare*) and 5% yeast at 25 ± 2°C and RH 93±2% to produce fattened (HILLYER & THORSTEINSON, 1971) adults. To determine the relationship between mating time and the reproductive potential of these insects, a newly emerged female was paired with a freshly eclosed male inside a glass vial serving as oviposition chamber (KRISHNA & NARAIN, 1976) for one of the three specified 4–hour periods (18.30 through 22.30; 22.30 through 2.30 and 2.30 through 6.30) during each 24–hour cycle of the first 5 days of the experiment. For the remaining part of the normal day–night rhythm, when the sexes were not paired, they were separated by metallic wire mesh partition.

Assessment of the mating potential between males and females of differing ages and appreciation of subsequent reproductive performance of these females were made on the basis of values obtained from a separate series of experiments wherein a single newborn moth was always paired for mating for 5 days from the start of the experiment, with 0, 3 or 6 day old adult individuals of the opposite sex. These males and females were housed together throughout their lives without any partition. Daily monitoring of oviposition from the day following pairing was also restricted to a 5–day period when the mated females were generally prolific in egg laying. The viability of the eggs was also ascertained.

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Female was often found capable of mating, within the 5-day tenure of the experiment, twice with the same male paired with her. Most of these copulations were performed during the first 2 days of the test period, although, occasionally, the pairs resorted to coitus even on the 4th day. The length of an individual mating act was quite brief and ranged between 2 and 8 minutes. Interestingly, females which copulated during the 4–hour interval (22.30 through 2.30) falling in the late night period deposited the highest number of total and fertile eggs, while those which completed this sexual function in the early scotophase (18.30 through 22.30) were least productive with respect to both yield and viability of eggs (Table 1).

Males or females as old as 6 days courted and mated with freshly emerged individuals of opposite sex. New born mated females showed an almost equal competency to unload eggs when copulated with 0, 3 or 6-day old males although the proportion of fertile eggs released by them was largest when such individuals were sexually united with freshly eclosed males (Table 1). The ovipositional activity and egg fertility of *C. cephalonica* appear to be regulated by age at the time of mating.

TABLE 1. Estimates of oviposition (based on a 5 day egg count made from the day following pairing) and hatchability of eggs laid by fattened mated females of *C. cephalonica* subjected to different time and age related mating schedules (data pooled from five females).

Experimental condition			Mean number of total eggs laid	Mean number of total viable eggs deposited
A. Concerning time period in each 24 hr cycle when male and female were paired for mating.				
(a)	18.30	through 22.30	119.4	63.6
(b)	22.30	through 2.30	175.2	132.2
(c)	2.30	through 6.30	143.6	79.2
B. Concerning age in (days counted from emergence) of sexes at the time of pairing.				
	Male	Female		
(a)	0	0	263.4	142.4
(b)	0	3	23.2	3.8
(c)	0	6	7.8	3.3
(d)	3	0	254.6	49.0
(e)	6	0	265.0	7.0

Acknowledgements:—One of us (SNM) expresses his sincere thanks to the University Grants Commission, New Delhi, for the award of a Teacher Fellowship which made it possible to undertake this investigation.

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BRIEF COMMUNICATION

BIOLOGY OF *ZABROTES SUBFASCIATUS* (BOH.) (BRUCHIDAE : COLEOPTERA)

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(*Received 17 August 1978*)

***Zabrotes subfasciatus* (BOH.) is a serious pest of *Phaseolus lunatus* and is available all the year round. Copulation lasts for 4–5 minutes. A single male can copulate with as many as 21 females. The female invariably indulges in second copulation. A gravid female lays maximum of 69 eggs and 29°C to 31°C range of temperature and RH of 70% are most suitable for oviposition. A maximum of 49 eggs have been recorded on a single seed. 14.5% eggs fail to hatch even under most favourable conditions; the mortality rate is even more higher in June and July. Three parasites have been found attacking the pest in immature and adult stages. Occasionally, the pest is also found damaging *Vigna sinensis*.**

Zobrotes subfasciatus (BOH.) is a small beetle, measuring 2.44 mm to 3.69 mm in length. and is a serious pest of *Phaseolus lunatus* (Harwan). It has also been observed doing some damage to *Vigna sinensis* (Rongi). A perusal of the literature reveals that though the pest has a significant economic importance, yet no biological details are available. However, HOWE & CURRIE (1964) have made some laboratory observations on the rate of development, mortality and oviposition on the bruchids including *Z. subfasciatus*. The present work includes observations on the biology and behaviour of the adult *Z. subfasciatus*. The observations were recorded under natural conditions of temperature and humidity in the laboratory.

Zabrotes subfasciatus is a common species and the stores containing *Phaseolus lunatus* (Harwan) rarely escape from its attack. It continues to develop throughout the year, however, in January and February its activities are slowed down. It prefers *Phaseolus lunatus* (Table 1) as its favoured food but a few other species of legume like *Vigna sinensis* (Rongi) and *Pisum sativum* (edible pea) also suffer mild attack.

The adults do not feed, though PADDOCK & REINHARD (1919), and ARORA (1977) have reported that the adults of the species of *Bruchus quadrimaculatus* and *Bruchidius* spp. feed actively in the fields. All the larval instars, which remain hidden in the seed, feed voraciously on the contents of the latter and come out only in the form of an adult.

The larvae as well as the adults of *Z. subfasciatus* have been found to be parasitized by the hymenopteran *Bruchicida orientalis* and *Bruchobious colemani* and by an arachnid *Pedicoloides ventricosus* as described by ARORA & SINGH (1969). Its mortality, coupled with strong attack of parasites is very high during the months of June and July, and even under optimum conditions of oviposition, 14.5% eggs fail to hatch.

Mating behaviour

Freshly emerged females and males are sluggish but the latter becomes active within

TABLE 1. Showing food preference (Temperature 29°C to 31°C and R H 70% to 80%).

	Grains	Total no. of eggs laid	Percentage of preference	
1	*Phaseolus lunatus* (red Harwan)	228	39. 8%	76.0%
2	*Phaseolus lunatus* (white Harwan)	208	36. 2%	
3	*Vigna sinensis* (Rongi)	63	10. 9%	
4	*Cicer gigas* (Safed Chana)	25	4. 3%	
5	*Cicer arietinum* (Kala Chana)	4	0.69%	
6	*Pisum sativum* (Edible pea)	29	5.06%	
7	*Phaseolus acontifolius*	16	2. 8%	

about 15 minutes, whereas, the former take 20 to 25 minutes to become careful of their surroundings. Mating can start at any time after an hour of emergence. Similar observations have also been recorded by ARORA & SINGH (1969) and RAINA (1971), whereas, ARORA & PAJNI (1957) have found that the copulation starts immediately after emergence in *Bruchus maculatus* (now *Callosobruchus maculatus*).

Feamle kicks off male with her hindlegs when not receptive. When receptive, her movements are being stopped by male after catching hold of her hindlegs. In an actual act, the male surmounts the abdomen of the female and tries to insert its intromitant organ into the female genitalia. Once the genitalia inserted, it let loses the legs of the female. The coition lasts for 4 to 5 minutes, after which the female takes the initiative to stop this process, by pushing away the male with her hindlegs. For the next mating, the female is never ready within the period of at least an hour but as far as male is concerned, it can mate with other females. On an average a male can impregnate 17.33 ± 1.802 females during its life span. PADDOCK & REINHARD (1919) have observed that a single male of *Bruchus quadrimaculatus* can fertilise only 8 females, whereas, a male of *Callosobruchus chinensis* can mate with 10 to 18 females (ARORA & SINGH 1969). The mating is not specific and it can take place at any time during twenty–four hours.

Oviposition

After copulation, a female starts laying eggs within 3 to 4 hours (August-September), 3½ to 10 hours (November-December) and 2 to 8 hours (March-April), depending upon the temperature. Before oviposition is initiated, female selects a healthy seed, it sits motionless on its surface for about one minute and extrudes a drop of slightly viscous fluid from its genital aperture, which it rubs on the surface of the seed with the help of the genitalia. After about half a minute, almost a rounded egg is deposited. 2½ minutes are required to lay a single egg. After laying each egg, the female turns around to check it with the help of her antennae.

Only four or five eggs are laid on a single seed, however, when less number of seeds are available, females lay as many as 49 eggs (Fig. 1). Maximum number of individuals emerged from a single seed was 28. The remaining fertilized eggs hatched, but development did not go beyond larval stages.

Period and rate of oviposition

The data show that the temperature range

TABLE 2. Showing number of eggs laid and the oviposition period at different temperature and relative humidity.

		Mean of eggs	SE	Oviposition period in days	SE
Temperature range RH	29°C–31°C 70%–80%	50. 6	± 3.44	6.94	± 0.25
Temperature range R H	22°C–25°C 56%–65%	33. 2	± 1.93	6.7	± 0.18
Temperature range RH	10°C–12°C 50%–55%	16.35	± 1.55	3.7	± 0.105

RH Relative humidity.
SE Standard error.

Fig. 1. Showing heavily infested seeds of *Phaseolus launtus* (Harwan) by *Zabrotes subfasciatus* (BOH.).

of 29°C to 31°C, and R H range of 70% to 80% is suitable for oviposition.

An average of 50.6 ± 3.44 eggs have been laid at temperature range of 29°C to 31°C and R H range of 70% to 80%, whereas, 16.33 ± 1.55 eggs at temperature range of 10°C to 12°C and R H 50% to 55%. It is also noticed that the number of eggs laid by females vary considerably at a given range of temperature and humidity, maximum being 69 eggs. It has also been observed that 35°C, the mortality rate increases considerably.

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BRIEF COMMUNICATION

EFFECTS OF TWO JUVENILE HORMONE ANALOGUES ON EMBRYONIC NEUROENDOCRINE SYSTEM OF *DYSDERCUS CINGULATUS* (HETEROPTERA, PYRRHOCORIDAE)

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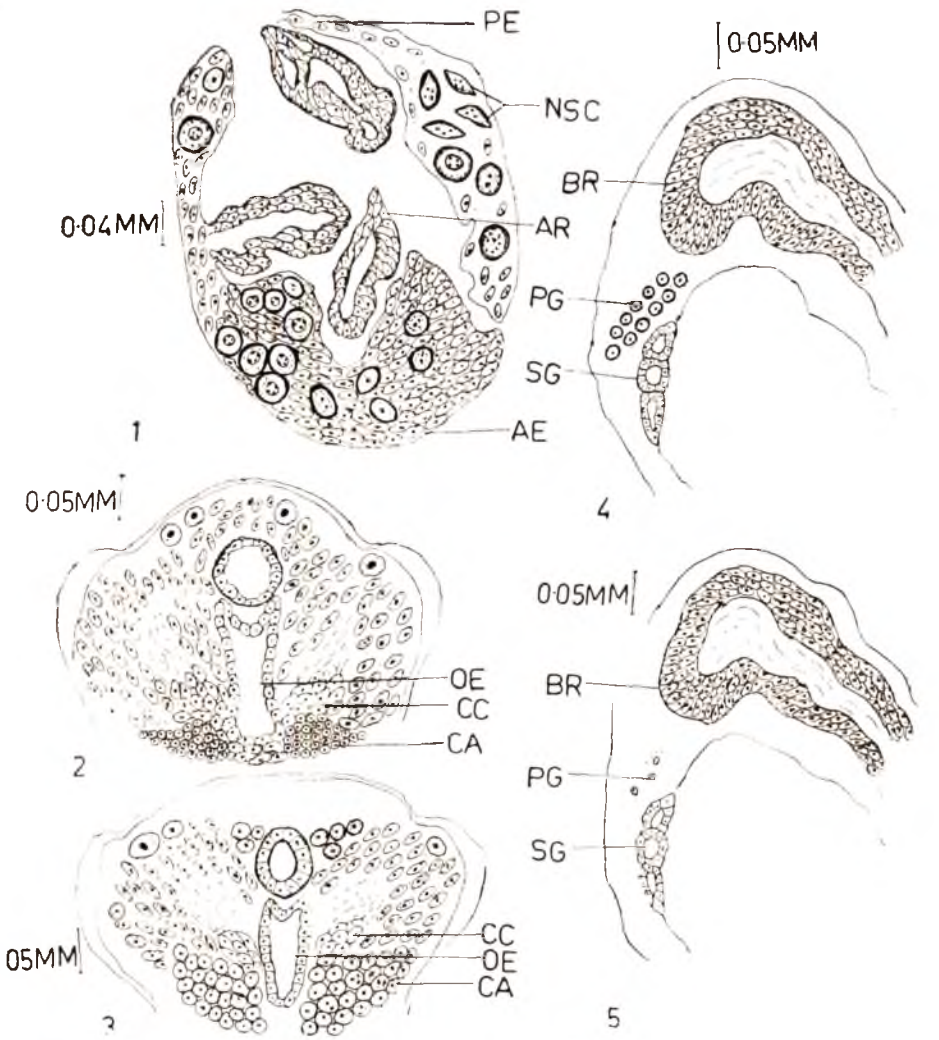
Two Juvenile hormone analogues farnesyl methyl ether and ZR 777 were topically applied to eggs of *Dysdercus cingulatus* and the endocrine organs were investigated in the different types of abnormal embryos obtained. The results showed that JH analogues influenced the embryonic neurosecretory cells, prothroracic glands and corpus allatum.

(*Key words:* **juvenile hormone analogues, farnesyl methyl ether, ZR 777, embryonic neuroendocrine system,** *Dysdercus cingulatus*)

Endocrine activity during insect embryogenesis was first reported by JONES (1956) in Orthoptera and subsequently by SHARAN & SAHNI (1960) in *Dysdercus ciugulatus*, by KHAN & FRASER (1962) in *Periplaneta americana* and by DORN (1972) in *Oncopeltus fasciatus*. Ecdysone activity in the eggs of *Bombyx mori* was detected by OHNISHI et al. (1971). The ability of exogenous juvenile hormone (JH) or JH analogues to block insect development is now well documented. RIDDIFORD & TRUMAN (1972) reported that exposure of insect embryos to JH analogues resulted in delayed effects which were realized later at metamorphosis. They suggested that JH possibly disrupted the embryonic programming of the corpus allatum so that it did not cease secretion of the hormone just before metamorphosis. Since this possibility has not been yet tested it was thought worthwhile to follow the changes in endocrine organs as a result of JH treatment of the eggs of *Dysdercus cingulatus*.

The JH analogues farnesyl methyl ether (FME, purchased from Eco Control Inc.) and ZR 777 (Kinoprene, a gift from Dr. G. B. STAAL of Zoecon Corporation, U.S.A.) were dissolved in acetone. Different doses of FME (2.0, 1.5, 1.0, 0.5 and 0.25 μg) and ZR 777 (0.25, 0.125, 0.06, 0.03, 0.015, 0.0075, 0.004, 0.0009 and 0.0001 μg) dissolved in 1 μl of acetone were topically applied to eggs after oviposition, after germ band formation and after blastokinesis, using a Hamilton microliter syringe. Controls were treated with acetone. Embryos were fixed in Smith's fluid, sections at 5μ thickness were stained in Gomori's chrom haematoxylin phloxin.

It was found that acetone had no effect on development. When eggs just after oviposition and after germ band formation were treated with the JH analogues different types of abnormal embryos resulted (MARIAMMA-JACOB & PRABHU, 1979). Eggs after blastokinesis were found to be less sensitive. The abnormal embryos obtained at high doses (FME 2 μg and ZR 777, 0.25 μg and 0.125 μg) were masses of cells with unusual crowding of nuclei. No organs could be distinguished in these embryos. At other



1. Sagittal section through non-segmented embryo treated 0.06 μg ZR 777 after oviposition showing scattered neurosecretory cells; 2. Transverse section through brain of late 4 day old control embryo showing corpus cardiacum and corpus allatum; 3. T.S. through brain of late 4 day old (0.0075 μg ZR 777 treated after oviposition) embryo showing corpus cardiacum and corpus allatum; 4. Sagittal section through head region of a 5 day old embryo (control) showing prothoracic glands; 5. Sagittal section through head region of a 5 day old treated embryo (1.5 μg FME after germ band formation) showing prothoracic glands. AE–anterior end; AR–appendage rudiment; BR–brain; CA–corpus allatum; CC–corpus cardiacum; NSC–neurosecretory cells; OE–oesophagus; PE–posterior end; PG–prothoracic gland; SG–salivary gland.

doses the effects on the endocrine organs were clearer.

The neurosecretory cells :

Normally the neurosecretory cells were evident in the 84 hr old embryo just after blastokinesis. They were distributed in the median, lateral and ventral aspects of the protocerebrum and were oval, spherical or pear shaped, being larger than the neighbouring neurones, from 84 to 98 hrs. They gradually became difficult to identify from the other neurones. In the treated embryos which had no other abnormalities but which failed to hatch, the neurosecretory cells developed apparently normally but in some of these embryos even at hatching the nourosecretory material was clumped together in the cells. The nonsegmented embryos with or without appendage rudiments showed the three types of neurosecretory cells which were larger and rich in secretion, and distributed throughout the differentiated region. In the dwarf embryos the neurosecretory cells were restricted to the protocerebrum. They were rich in secretion and were often found shifted to the inner parts of protocerebrum thus lacking the regular arrangement. In non segmented and dwarf embryos the neurosecretory material became evident at 84 hrs and in non segmented embryos the size of the cells never got reduced comparable to those of the controls.

Corpus cardiacum and corpus allatum :

During normal embryogenesis the corpora cardiaca (CC) developed as paired structures from the dorsolateral regions of the stomodaeum and the corpus allatum (CA) originated from the mandibular segments. They made their appearance at 78 hrs before the revolution of the embryo. In a 4 day old embryo CC and CA were found in close communication. In the nonsegmented embryos no trace of CC or CA were seen. In the dwarf embryos they appeared at 78 hrs like the controls but their size was found to be reduced. Fully developed embryos showed CC having the normal size. The CA also developed normally but the cells were bigger.

Prothoracic glands :

In the normal embryo, prothoracic glands appeared at 76–78 hrs as a pair of invaginations from the 2nd maxillary segment along with salivary glands. At 84–88 hrs they extended backwards into the thorax along with salivary glands. They were a pair of bands of large cells loosely embedded in the connective tissue extending between posterior cerebral lobes and the salivary glands. In the non-segmented embryo no trace of prothoracic glands were seen. In the dwarf embryos the number and size of the cells were reduced and in some they could not be distinguished. In well developed embryos having no visible abnormalities but which failed to hatch, in most cases the prothoracic glands degenerated and the number and size of the cells were reduced. In the embryos continuing development inside the chorion without hatching well developed cells comparable to those in the controls were evident.

JONES (1956), SHARAN & SAHNI (1960) and DORN (1972) have reported that the neurosecretory cells and prothoracie glands were well functioning during insect embryogenesis. In the present study the crowding of neurosecretory material and the abnormality in prothoracic glands showed abnormal activity during embryogenesis in treated embryos. SLAMA et al. (1974) observed that JH analogues did not stimulate the activity of prothoracic glands in starved nymphs of exopterygotes and in diapausing larvae or pupae of endopterygote insects other than Lepidoptera.

The corpora allata in the embryos of *Dysdercus cingulatus* showed no cyclic changes during embryogenesis (SHARAN & SAHNI, (1960). In the present study the JH treated embryos showed enlarged cells of the corpora allata than the controls. RIDDIFORD & TRUMAN (1972) suggested that the delayed effects in metamorphosis of JH treatad insect embryos may be due to a reprogramming of the embryonic corpora allata. The increased cell size of the corpora allata resulting thereby in an enlargement of the gland as a whole observed during the present study appears to support this view.

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BRIEF COMMUNICATION

SPECTRAL SENSITIVITY AND BEHAVIOURAL RESPONSE OF DIAPAUSE LARVAE OF *TROGODERMA GRANARIUM*

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(*Received 1 March 1979*)

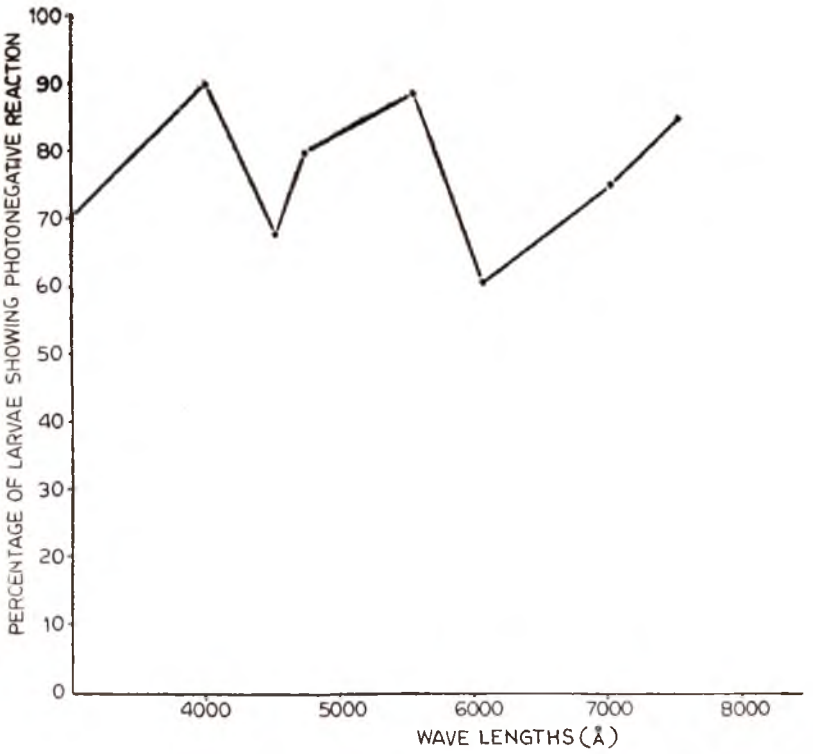
Photosensitivity of the diapause larvae of *Trogoderma granarium* was studied under various wavelengths of the light spectrum. Larvae showed high sensitivity at 400nm (violet) and 560nm (green). At different wavelengths of individual colour, larvae behaved differently, a progressive increase in activity was registered as the wavelength increased.

(*Key* **words: spectral sensitivity,** *Trogoderma*, **diapause)**

Trogoderma granarium is a serious pest on stored grains, doing considerable damage by feeding at the larval stages and by contaminating the food with their excreta. Larvae of this insect, though active, prefer to aggregate themselves in refuges such as cracks and crevices of the godowns and any other available space, to avoid exposure to light (BURGES, 1959; 1963). This tendency is more pronounced in diapause larvae. Photosensitivity of the larvae and adults of *Trogoderma* was first reported by RAHMAN & SOHI (1939). Though adults were reported to be photosensitive and mate during night (VOELKEL, 1924), KARNAVAR (1972) has reported that they mate during day time in well illuminated arena.

Literature on photosensitivity of larvae of stored grain pests is scanty; adults of certain beetles were found to be sensitive to wavelengths of green and violet (STERMER, 1959). Preliminary studies on the reaction of *Trogoderma* larvae to different wavelengths in the visible region of the light spectrum was undertaken by YINON & SHULOV (1965). No information is available regarding the behaviour of diapausing larvae of this insect and their sensitivity to ultraviolet and other wavelengths in the same visible region. The present study was undertaken to elucidate the spectral sensitivity and behavioural response of diapausing larvae of *T. granarium* exposed to different wavelengths.

Trogoderma larvae were maintained on crushed wheat at 35 ± 1°C and 70% RH (KARNAVAR, 1967). At this temperature, under crowded conditions, 70% of the larvae pupate within 30 days. The remaining larvae were transferred to fresh food and maintained at 30°C. After 45 days of emergence, those larvae which failed to pupate were considered to be in diapause. Wavelengths ranging between 300 and 750 nm produced with a Grating Monochromator (Bausch & Lomb) and a mercury source were used. A visometer was constructed with a length of 50 cm, width 2 cm and height 3 cm. A window was made at one end and covered it with quartz. The entire visometer except the window was made light proof. 10 to 15 diapausing larvae were used for each observation. Larvae were introduced near the window and the desired region of the spectrum was allowed to pass through the window. The experiments were conducted



PHOTONEGATIVE RESPONSES OF DIAPAUSING LARVE OF I GRANARIUM

in a dark room. Reactions of 50–100 larvae were tested for each wavelength. The duration for each trial was 20 minutes. The behaviour of the larvae was judged from the distance moved by them from the window to avoid light.

Five regions of the light spectrum were selected for the present study. The results obtained are presented in Fig. 1. The reaction of the diapausing larvae to these five regions showed an increased sensitivity from the ultraviolet to violet (60.6% to 90·4%) and a decline from violet to red. The percentage of larvae showing photosensitive reaction at 400 nm (violet) was 90.4; at 450 nm (blue) was 67.6 and at 610 nm (red) was 60.5. These results agree in general with the findings of YINON & SHULOV (1965). In their study with normal larvae of *Trogoderma*, they have found that the photonegative response was increasing when the applied wave length became shorter. However, contrary to the report of YINON & SHULOV (1965), at 560 nm (green) diapause larvae showed an increased photosensitive reaction (88%). Eventhough there was a preference for longer wavelengths (when the spectrum as a whole was taken into consideration), as evidenced by the above results and that of YINON & SHULOV (1965), diapause larvae showed a capacity to discriminate closer wavelengths of the same colour. Results of the reaction of the larvae under blue and red regions of the spectrum substantiate this. In the blue region at 450 nm, only 67.6% of the larvae were photonegative while at 470 nm in the same

region 81.1% larvae were sensitive. Similarly in the red region at 610 nm, 60.5% of the larvae showed photosensitivity; whereas at 700 nm, 75% and at 750 nm 80% of the larvae exhibited photonegative reaction. Here, as wavelengths increased the sensitivity also increased. Though diapasue larvae were sensitive to shorter wavelengths, they reacted differently to ultraviolet light. Only 70.6% of the larvae showed sensitivity at 300 and 350 nm. It is evident from the present study that diapause larvae of *Trogoderma* are less sensitive to longer wavelengths in the visible region of the spectrum except green at 560 nm. They reacted differently to different wavelengths of the same colour, with a progressive increase in photosensitivity as the wavelength increased.

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BRIEF COMMUNICATION

DIMETHOATE RESIDUE IN PEPPER *(PIPER NIGRUM)*

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(Received 25 November 1978)

Spraying of dimethoate (Rogor 30 EC) at 0.06, 0.1 and 0.15 per cent concentrations once at the time of bearing left residues below detectable, 1.42 and 2.17 ppm respectively in the green pepper harvested 15 days after spraying. A residue of 0.31 ppm was determined by bioassay for 0.15 per concentration while it was below detectable level in respect of other two lower concentrations.

(Key words: **dimethoate, residue, bioassay)**

Dimethoate is one of the systemic insecticides commonly used on a variety of crops to control insect and mite pests. *Pollu* beetle, *Longitarsus nigripennis* M. is a serious pest on pepper in west coast areas which causes about 30 to 40 per cent loss. The grubs bore into the ripening berries and feed on the seeds making them hollow. PILLAI & ABRAHAM (1974) have reported that spraying of dimethoate at 0.1% twice controlled this pest effectively. In this paper, the results of residues of dimethoate (Rogor 30 EC) determined in green pepper has been reported.

Samples of green pepper (Var: Panniyur) sprayed with Rogor 30 were collected from Kottayam, Kerala State and analysed for residue determination. The insecticide at three concentrations (Table 1), was sprayed once at the time of bearing during August, 1978 and composite samples were collected 15 days thereafter from the respective treatments. Analytical methods recommended by the Joint Dimethoate Residue Panel (ANONYMOUS, 1968) were followed with slight modifications as indicated for chemical assay while for bioassay that of SUN *et al.* (1965). Acetone extract of the sample was extracted twice with 50 ml of hexane before partitioning with chloroform in order to ensure that no oily substance interfered seriously in the wet oxidation

TABLE 1. Residues of dimethoate (Rogor 30 EC) in green pepper

Concentrations %	Residues in ppm (15 days after application)	
	Chemical assay	Bioassay
0.06	ND	ND
0.10	1.42	ND
0.15	2.17	0.31

ND = Nondetectable

stage. Further, 5 ml of nitric acid was used in the wet oxidation stage instead of 5 drops since it was found insufficient to digest the material to a colourless liquid.

Data on the residues of Rogor estimated for the three concentrations are furnished in the Table.

In general, it was observed that the level of residues in green pepper showed an increasing trend as the concentration increased. The lower concentrations viz., 0.06 and 0.1 per cent recorded residues in chemical assay well below the tolerance limit of 2 ppm set for most of the condiments like peppers whereas the residues were below detectable level in bioassay. A residue of 2.17 and 0.31 ppm was recorded respectively by chemical and bioassay methods for 0.15 per cent concentration.

The data thus indicate that spraying of Rogor 30 EC at a concentration not exceeding 0.1 per cent is found to be safe when the pepper is to be used as green condiment.

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REPORTS AND NEW RECORDS

SYNCEPHALASTRUM RACEMOSUM COHN EX SCHROETER, AN ENTOMOGENUS FUNGUS OF RICE LEAF-HOPPER *CICADELLA SPECTRA* (DIST.)

Cicadella spectra (Dist.) (Cicadellidae: Hemiptra) occurs as a wide spread pest of rice in Kerala and other rice growing tracts of the country. During July–August, 1978 nymphs and adults of the insect were seen killed by an epizootic infection in the rice fields of the College of Agriculture Farm at Vellayani. A fungal pathogen was isolated from the killed insects in pure culture on potato dextrose agar and was identified as *Syncephalastrum racemosum* Cohn ex Schroeter. This was the first record of a microbial disease on this insect in India. GABRIEL (1970) had reported *Entomophthora* on this insect from Philippines. Pathogenicity tests conducted by spraying spore suspension prepared from 5 day old cultures of the fungus showed that it was highly pathogenic to nymphs and adults of the hopper causing more than 85 per cent mortality.

The infected insects became sluggish and were less responsive to external stimuli. Death occurred in 24–48 hours. The body assumed a brownish colouration towards death. The cadavers were soft to touch immediately after death but later became hard. External mycelium appeared in 48 hours. Majority of the dead insects remained stuck to the leaves with their wings stretched while others dropped to the soil.

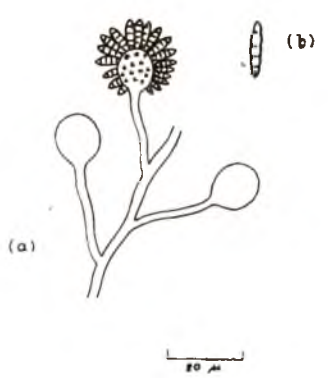

Fig. 1. *Syncephalastrum racemosum*
(a) Sporangiophore (b) Merosporangium.

The characteristics of the fungus in artificial cultures were as follows: Mycelial turf at first white and later grey. Sporangiophores richly branched with curved laterals (Fig. 1). Fruiting head globose, 26–50μ in width, with numerous small warts to which 5 to 10 spored merosporangia were attached. The spores irregular in size and mostly globose 2.8 to 5 μ. Germination of spores commenced in 24 hours.

The authors are thankful to Mr. P. M. KIRK, Commonwealth Mycological Institute, Kew, England, for identifying the fungus.

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NEW RECORD OF A PEST OF BRINJAL

Luperomorpha bombayensis Jac. (Chrysomelidae: Halticinae) was observed for the first time feeding on and damaging flowers of brinjal (*Solanum melongena*) in the Agricultural College Farm, Vellayani, Kerala State, during October–December 1978.

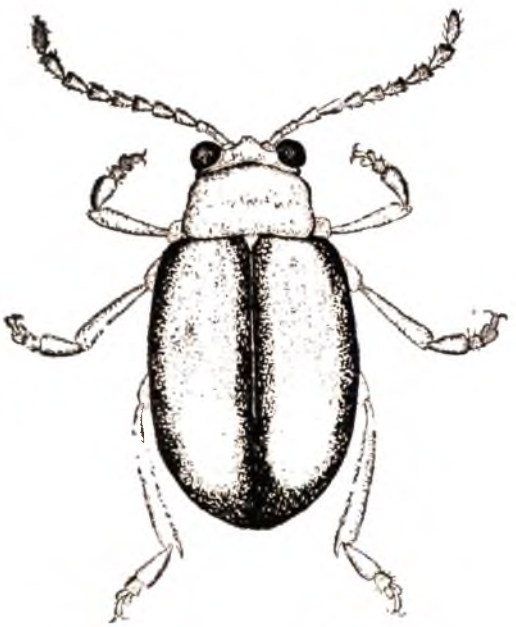

Fig. 1. *Luperomorpha bombayensis*.

L. bombayensis has been originally described from specimens collected at Belgaum and Dharwar (MAULIK, 1926). It is a small dark flee beetle, the female measuring 3 to 3.25 × 1.5 mm and male 2.5 × 1.25 mm. The head and prothorax are pale brown. The elytra have the suture, lateral margins and apex blackish, rest of the elytra surface being yellowish brown (Fig. 1). Antennae and legs are brown turning dark distally. Underside of abdomen is blackish-brown.

The beetle is active and jumps and flies away when disturbed. The flowers are infested by the beetle in large numbers and they eat away completely the stamens and pistil. The sepals too are damaged by feeding. The damage to the flowers on plants is seen to be often total, preventing formation of fruits. The infestation can be controlled by a single application of a contact insecticide.

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23-12-78

BOOK REVIEW

INVESTIGATIONS ON INSECT PESTS OF SORGHUM AND MILLETS WITH SPECIAL REFERENCE TO HOST PLANT RESISTANCE, Ed. M. G. JOTWANI, Division of Entomology, Indian Agricultural Research Institute, New Delhi, 1978, 114 pp.

This is the final technical report of the work done on the topic during 1972–77 under a PL 480 project. The major part of the report relates to studies made on the relative resistance of a large number of varieties of sorghum, both of exotic and indigenous origin, to infestation by the shoot fly and stem borer individually and in combination (multiple resistance) and by the grain midge. Results of studies on the mechanism and inheritance of shoot fly resistance of sorghum as well as on the possibility of improving insect resistance of sorghum by mutation breeding are presented. Relative susceptibility of seeds of released sorghum hybrids to infestation by storage pests is indicated. Besides these, observations made on the biology and bionomics of major pests of sorghum and of the pests of millets are given. Future lines of work are indicated.

The report will be useful in selecting pest resistant varieties of sorghum suitable for cultivation and for serving as breeding materials in resistance breeding programme.

M. R. G. K. NAIR

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